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NEW YORK, APRIL, 1887.

THE office of the RAILROAD AND ENGINEERING JOURNAL will, on May 1 next, be removed from No. 23 Murray-street to No. 45 Broadway, New-York City. All communications intended for the JOURNAL, its proprietor or its editors, should be addressed to No. 45 Broadway from May 1 next.

THE carefully prepared table which we reprint in another column shows that up to the adjournment of Congress, on March 4, the Navy Department had been authorized to construct ten steel cruisers and fighting vessels of large size, five gunboats, one dynamite cruiser and one torpedo boat, and also to complete the five double-turreted monitors which have for years been in an unfinished condition. This will give the Navy a total of 22 vessels built and armed in accordance with modern practice, four of which are already in commission or will shortly be so. The total amount appropriated for these vessels has been $31,000,000, a very respectable sum, and in addition the amount of $2,150,000 has been appropriated for torpedoes and for special vessels for harbor defense.

There is no doubt that the judicious expenditure of the appropriations will be ot great service in giving the country the beginning or foundation of a navy worthy of its reputation and standing, and armed in accordance with modern ideas.

THE Army did not fare so well as the Navy in the late Congress, the Fortification bill having failed in the hurry of the close of the session. Little or nothing can therefore be done in the way of new forts or armament during the present year, but there will doubtless be much discussion over the many plans proposed. The old gun-and-armor controversy continues active, and arguments have been brought up on both sides of the question, although it would seem that nothing more could be learned by discussion, and that the time had arrived when actual experiment is needed. So much has been done in this line in Europe, however, that such experiments as can be made in this country will add but little to our actual knowledge, except, perhaps, in one direction.

THE use of the Rodman gun, or of guns cast on the Rodman plan, substituting steel for the cast-iron originally used, is urged by Mr. William Metcalf, in his paper read before the American Society of Civil Engineers, an abstract of which will be found in another column. Mr. Metcalf is a high authority on all questions relating to steel, and his paper certainly presents a very strong argument in favor of the Rodman gun, as opposed to the "built-up" gun of forged steel—so strong as to make it appear wise to give this system a thorough trial before spending large amounts in turning out guns on the more expensive plan which has found favor in Europe.

THE execution of the Interstate Commerce bill is to be entrusted to a board composed of lawyers. One of these lawyers, however, has had a large experience in railroad cases and is considered high authority not only on railroad law, but also on questions of traffic and rates. Another has been engaged in important railroad cases, while a third has had four years' experience as head of a State commission under a law which permits very strict regulation of railroads. To obtain the services of a man with practical experience in railroad management and of a standing high enough to command public confidence would have been extremely difficult, if not impossible, and the President has made about the best commission that could have been selected under the circumstances.

IN March, as in February, the meetings of the various railroad clubs were largely occupied in discussing the question of car heating. Not much that was new was brought forward at any of the meetings, the time being largely taken at all by explanations of various systems of heating, either proposed or in actual use. Very little more can be done in an experimental way this season, and the subject will go over to next winter, when, probably, the interest in it will be less active than now, lacking the stimulus given by the terrible accidents of the past winter.

A VERY common opinion seems to have been pretty accurately summed up by Mr. Lauder at the New York meeting, when he expressed his belief that "continuous heating" was bound to become as general in its application to passenger trains as continuous brakes. He had not yet seen his way clear to the adoption of any of the proposed systems, but he had very little doubt that one would be devised that would meet all the present objections. The main point which Mr. Lauder urged was the adoption of a uniform coupling which should make it possible to exchange passenger cars without interfering with the heating arrangements.

Mr. Forsythe, speaking in Chicago at almost the same time, expressed views very nearly identical with those of Mr. Lauder, and, like him, expressed pretty accurately a general current of opinion.

THE use of electric motors for light machinery in towns and cities, where power can be transmitted from a central station, presents a very promising field for the future. There is a large and increasing demand for power in nearly

all our cities, and if the electricians can meet this demand by motors which are easily controlled, safe and not too expensive, there is no doubt that they have a great opportunity. A paper read at the Electric Light convention in Philadelphia by Mr. Sprague called out much discussion and much interest among electrical engineers. The use of electricity in transmitting power is still in the first stages of development, and much is to be expected from it in this direction.

THE EFFECT OF COLD ON RAILROAD AXLES.

THAT cold makes iron and steel brittle is the general opinion of people who have more practical experience than scientific knowledge. But notwithstanding this popular impression the experiments which have been made by scientists show very contradictory results. Some of them assert that "the absolute or tensile strength of iron and steel is not diminished by cold," and Dr. Poule, after making a series of experiments, concluded that "frost does not make either iron (cast or wrought) or steel brittle." Other investigators have, however, reached quite different conclusions. But the common experience of practical men and scientific investigation both indicate that when iron or steel is at a very low temperature the effect of transverse sudden impact is very different from that of a steady tensile strain, and that when such metal is warm it is less liable to fracture by a sudden blow than when it is cold. To throw some light on this important subject Mr. Thomas Andrews made a series of experiments with full-sized railway "carriage" axles, manufactured at the Wortley Iron Works. These axles were made from clean selected scrap iron. Forty-two complete axles were tested, and the results of his researches are given in a paper published by the Institute of Civil Engineers. The axles were tested by the impact of a falling weight of 2,240 lbs. Two tanks were arranged so that some of the axles were immersed in a freezing mixture in the one tank, and others were placed in a warm-water bath in the other tank. Great care was taken to ascertain the temperatures of the axles that were tested. After being immersed in the freezing mixture or the warm bath they were carefully adjusted in the supports—3 ft. 6 in. apart—of the testing apparatus. The ball, or test weight, was then allowed to fall on the center of the axle from the elevation recorded. The axle was then re-immersed in one of the tanks, and again withdrawn and placed in the testing apparatus, receiving another blow from the ball, but in a reverse direction from the first, as the axles in each case were half turned over after every blow. In the first set of experiments one axle, tested at a temperature of from 7° to 10° Fahrenheit, broke after the third blow of the weight falling 10 ft., and another broke after the second blow. Three others were similarly tested at a temperature of 212°. They broke after the fifth, seventh and thirteenth blows respectively.

In another series of tests the axles were subjected to the blows of the weight falling 15 ft. Two of them also were at a temperature of 7° and two at 120°. The cold axles both broke after the second blow, and one of the warm ones broke after the third, and the other after the fifth blow.

A third series of tests was made with some axles at a temperature of from 7° to 10° and others at 100°, with the weight falling 10 ft. For convenience of comparison the three series of tests are tabulated below:

FIRST SET OF TESTS, WEIGHT FALLING 10 FEET.

COLD TESTS.		WARM TESTS.	
TEMPERATURE OF AXLE 7° to 10°.		TEMPERATURE OF AXLE 212°	
Axle No. 2	3 Blows.	Axle No. 4	5 Blows.
" " 12	2 "	" " 5	7 "
		" " 7	13 "

SECOND SET OF TESTS, WEIGHT FALLING 15 FEET.

TEMPERATURE OF AXLE 7° to 10°.		TEMPERATURE OF AXLE 120°.	
Axle No. 8	2 Blows.	Axle No. 10	3 Blows.
" " 9	2 "	" " 11	5 "

THIRD SET OF TESTS, WEIGHT FALLING 10 FEET.

TEMPERATURE OF AXLE 7° to 10°.		TEMPERATURE OF AXLE 100°	
Axle No. 15	6 Blows.	Axle No. 14	5 Blows.
" " 16	9 "	" " 17	6 "
" " 18	3 "	" " 20	3 "
" " 19	6 "	" " 21	5 "
" " 22	1 "	" " 13	6 "
" " 24	4 "	" " 25	10 "
" " 26	4 "	" " 27	11 "
" " 28	4 "	" " 31	8 "
" " 29	12 "	" " 32	12 "
" " 30	6 "	" " 33	9 "

FOURTH SET OF TESTS, WEIGHT FALLING 10 FEET.

TEMPERATURE OF AXLE 7°.		TEMPERATURE OF AXLE 100°.	
Axle No. 3	23 Blows.	Axle No. 13	19 Blows.
" " 6	34 "		

With reference to these experiments the author of this paper says: "It will be noticed that Nos. 15, 16, 19 and 29 of the cold tests appeared exceptional to the general principle, enduring a greater total mean force before destruction than the axles in the warm tests of this set. The respective halves, therefore, of each of these axles, were turned down to 4½ inches diameter throughout and again tested, the one half at a temperature of 10° F., and the other at 100° F., but otherwise under the equal conditions employed in case of these axles when whole." In the second tests the warm half in each case had very much greater resistance than the cold half, of which the author says: "From this it will be seen that the results were confirmatory of the rule; the apparent deviation from the general uniformity was possibly due to some molecular difference in the material composing the several axles."

Of the fourth set of tests the experimenter remarks that, "Although these axles afforded exceptions to the general principle, yet when the halves of each axle were again tested respectively at 7° and 100°, the warm axles stood considerably more than the cold."

While the preponderance of evidence furnished by the above experiments indicates that the warm axles had greater power of resisting the blows to which they were subjected than the cold ones had, yet the results are not at all conclusive. To explain a deviation of the behavior of some axles from the others by saying that it "was possibly due to some molecular difference in the material composing the several axles" is, in substance, saying that the tests proved what the experimenter did not expect or want them to prove. If the greater power of endurance of some of the cold axles is "due to some molecular difference," then it is of the utmost importance to find out the real nature and cause of that difference, and, if possible, learn how to make axles having a molecular structure which will give such an increased power of resistance. It may be, and probably is, true that one kind of material

will resist blows better when cold than when it is warm, while another quality might stand more at a high temperature than at a low one.

Furthermore it may be that a cold axle, of a given quality, will resist light blows better than a warm one, whereas the reverse might be true if the blows were heavy. It is said to be a well-known fact, that steam-hammer piston-rods, made of hard steel, will stand many times longer than soft steel; whereas, if they were subjected to transverse destructive blows, similar to those with which the axles were tested, no doubt soft steel would stand more of them than hard steel. The author of the paper quoted from says "that an increase in the extent of the first deflection at the first blow has an influence on the after endurance of an axle, and consequently he is of opinion that in testing axles by impact, the application of a number of lesser impacts is preferable to the extremely heavy test-blows required in the specifications of some railway companies."

An examination of broken journals generally shows that the fracture commences with a circumferential crack at the throat or inside fillet. These cracks appear to extend gradually toward the center of the axle until the amount of solid metal which remains is not sufficient to hold up the load on it. How long it takes for such fracture to extend from the surface inward is probably not known, but it appears certain that what should be aimed at is to prevent the initial fracture at the surface and it may well be that a hard and comparatively brittle material will do this better than one which is soft and ductile, while, at the same time the former would stand fewer destructive blows than the latter.

All that the experiments of Mr. Andrews seem to prove is, that with the special quality of axles which he tested, most of the warm ones stood more destructive blows than the cold ones did. What the result would be if the test-blows were lighter or the material different, it remains for future experiments to determine.

THE BUSSEY BRIDGE ACCIDENT.

After a great calamity like that which happened in the Boston & Providence Railroad, from the failure of a bridge on March 14, there is always a great deal of very loud interrogation about the cause of the accident, and the responsibility for its occurrence. No doubt the official investigation of the Railroad Commissioners will show the origin of the disaster, and fix the blame where it belongs, so that it will hardly be worth while to say anything now about the construction of the bridge, especially as all the facts relating to it will probably be brought out more fully and accurately by the official investigation than they have been by the newspapers or can be by any casual inspection. The fact that the bridge broke down is incontrovertible evidence of defective construction. The question then naturally arises, were the defects discoverable, and if so, why was it permitted to remain in service? The Boston & Providence Railroad is a rich corporation, abundantly able, financially, to have all its equipment of the very best kind. Its list of officers, however, does not show nor has it appeared in the public discussion that a competent engineer is employed by the Company. This probably means that the responsibility for the condition of the bridges on its road, has not been delegated to a person with the ability and experience required to discover defects in their design and construction. This is not unusual, and the importance of competent engineering ability, in the management of railroads is either partially or entirely ignored. Directors and traffic managers are generally persons who have had an exclusively mercantile training, the value and importance of which is not questioned. But those who have been educated exclusively in the school of barter very often have a defective appreciation of the inexorable character of physical laws. Somehow or other that kind of people often find it difficult to rid themselves of a secret, lurking feeling that by skillful finesse they can "corner" the laws of nature. This is often amusingly illustrated by the way new inventions are "promoted" in Wall Street and its precincts. Those who engage in such projects sometimes seem to regard the scientific principles on which the invention depends, as a mere incident which can always be twisted to suit their purposes by a hired expert. In the same way, successful grocers and "bankers" feel, that by dispensing with the services of an engineer, at a fair salary, and delegating his duties to a "gang boss," that they can "beat" the law of gravitation and the principles of statics. These often take their revenge, as they did on the Boston & Providence Railroad, and as they have done and will do in other like cases.

Another very common evil is that of depriving the persons in charge of the engineering departments of railroads of the authority which they should have if their responsibility is more than a mere name. It is of course true that the business of a railroad is to carry freight and passengers, and to get pay for it, and that the financial and traffic departments should be conducted with reference to earning reasonable dividends, and further, that this conduct requires a special kind of ability, knowledge and experience quite different from that needed to construct and maintain a railroad and its equipment so as to give the maximum efficiency. But because this is the case, it does not follow that those in charge of the permanent works or machinery should be made subordinate to the traffic or the accounting departments, as they often are There must be a commander-in-chief of some kind of every railroad, with deputies below him. What is advocated here is that there should be, on every railroad, a competent deputy in charge of the permanent engineering works of the road and another in charge of the machinery and rolling stock, and that these deputies should have coördinate authority and power with those in charge of the other departments. If there had been a competent person entrusted with the responsibility of the bridges on the Boston & Providence Railroad, with no authority over him excepting that of the commander-in-chief and his council, it is not probable that such a structure, as the Bussey bridge evidently was, would have been allowed to remain in service. The failure of the Glens Falls bridge on one of the Delaware & Hudson Canal Company's leased lines in 1883, and that at Scottsville on the Buffalo, New York & Philadelphia Railroad, in the same year, were due to this same lack of responsibility. In their report on the former accident, the Railroad Commissioners of New York said: "The Board also censures the management of the Delaware & Hudson Canal Company, specifically for failing to have the bridges and trestles on its lines of roads properly tested and examined. Through the absence of such examination under a well-regulated system this disaster occurred. For divided responsibilities

and incompetency in the performance of their duties by subordinates, such as is here disclosed, a railroad corporation is primarily and legally responsible."

Drawing-Room Car-Seats.

THE experiment is now being tried on the Boston & Albany Railroad of substituting some of M. N. Forney's double seats for chairs in the drawing-room cars. A few of these seats have been put into several of the cars, which are now running in the trains which leave Boston and New York daily at 4.30 P. M. For the same price that is now paid for a single chair, the passenger will be entitled to the exclusive use of one of these seats. The chief attraction of drawing-room cars for passengers is their exclusiveness; that is, persons by paying for it can secure a seat to themselves. It is not intended to take that feature away from these cars by the introduction of the "sofa seats," as they are called, which have all the elements of comfort that chairs have. The latter are, however, limited in size, and do not allow of much change of position to those who occupy them, whereas the "sofa seats" give double the space, and occupy no more room lengthwise in the car than the chairs do, so that the railroad company can afford to give the privilege of occupying the one at the same price that is charged for the other. The double seat, if occupied by one person, gives sufficient room to permit of more change of position than is possible in a chair; and it also gives space for books, baggage or parcels. Revolving chairs always create a liability of trespass by neighboring passengers on each other's territory, which, to ladies, is often unpleasant, not to use a stronger term. Double seats with reversible backs also have the advantage that they allow passengers to sit much nearer to the windows than is possible in revolving chairs. Consequently the person in the seat has a much wider range of vision when looking out of the window than he has when sitting in a chair, which must be placed some distance from the side of the car so as to have room to turn.

As mentioned above the sofa seats have been put into the cars referred to as an experiment; that is, to determine whether they will be popular with passengers.

NEW PUBLICATIONS.

THE ROMANCE OF INVENTION.—BY JAMES BURNLEY. Cassell & Co. (Limited), London, Paris, New-York and Melbourne.

IN this book, as the author says in the opening sentence of his preface, "Some of the more romantic features of the history of invention have been described, apart from their technical surroundings." The book covers a wide range of subjects beginning with inventions in prehistoric ages, and a chapter on the dreams of the alchemists, and another on the martyrs of invention. The description of the persecutions of inventors in the "good old times," when people were beheaded and tortured because they happened to think differently from their neighbors, gives a picture of society which at the present day seems to be quite impossible. One of the most interesting chapters in the book is that relating to the phantoms of inventors. The chapter relating to the inventions of persons for secret murder, gives an insight into one of the darkest phases of human nature, which now, happily, has nearly or quite disappeared. The title of the book would perhaps give the impression that it treated of invention in the arts, to which the term is generally applied. Instead of that the author has burrowed into all kinds of curious places, and he shows the many and varied channels in which human ingenuity has been employed. Castles in the air; Inventors in Love; Poverty of Inventors; Fashion; Royal and Noble Inventors; Inventions of Punishment: of Costly Machinery; of Toys; Inventors on the Sea; Amongst the Wires; Discoveries by Accident; of Wheels; of Weapons; of Cooks; of Music: in Fire and Smoke; and Books and Literature—are the titles of different chapters.

The book is written in a popular style, and contains much curious information. The probabilities are, though, that a careful study of the lives of many inventors would reveal much more thrilling romance than any which the author has collected in his somewhat discursive chapters. If it were possible to discern and reveal the dreams, the hopes, the disappointment and often the despair of those whose expectations are centered in the Patent Office, it would make a picture more romantic, more pathetic, and often more tragic than any of the chapters in the book before us.

BOOKS RECEIVED.

SHOPPELL'S MODERN HOUSES. *Number 5*. Published at 191 Broadway, New York. Containing designs for houses and other buildings.

UNITED STATES GEOLOGICAL SURVEY—MINERAL RESOURCES OF THE UNITED STATES, 1885. Washington: Government Printing Office.

INTERNAL COMMERCE OF THE UNITED STATES, 1886. Washington: Government Printing Office. This is Part 2 of the Report on Commerce and Navigation, prepared by Wm. F. Switzler, Chief of the Bureau of Statistics. It contains elaborate reports on the productions and trade of a number of Southern States, and some valuable statistics of Southern railroad traffic.

MISURE DI VELOCITA NEL TEVERE. Paper by Professor Ildelbrando Nazzini. Published by the Royal School of Engineers, Rome, Italy.

ANNUARIO; SCUOLA D'APPLICAZIONE PER GL'INGEGNERI, 1886-87. This includes the programme and announcement of the Royal School of Engineers, which is a department of the University of Rome; also catalogues of the library, etc. Italian engineers are taking high position in Europe, and the faculty of the School includes several distinguished names.

THE KINDS AND GRADES OF BELTING TO USE FOR DIFFERENT KINDS OF WORK. The Page Belting Company, Concord, N. H. This pamphlet contains a number of practical rules and directions for the purchase and use of belting, which will be very convenient for the use of millwrights and others.

REPORT OF THE REGENTS' BOUNDARY COMMISSION UPON THE NEW-YORK AND PENNSYLVANIA BOUNDARY, WITH THE FINAL REPORT OF MAJOR H. W. CLARKE, C. E., SURVEYOR FOR THE COMMISSION. Albany: Weed, Parsons & Co.

THE JOURNAL OF THE IRON AND STEEL INSTITUTE, 1886, VOLS. I. AND II. E. & F. N. Spon, London and New York.

OBITUARY.

MR. ESTUS LAMB, for many years a prominent manufacturer, died in Providence, R. I., March 9, aged 77 years. Mr. Lamb was half owner of the large cotton mills at Putnam, Conn., and was interested in many other enterprises. He had been for 25 years a director of the Providence & Worcester Railroad Company, and President of the company for three years past.

LIEUTENANT JOSEPH S. POWELL, of the U. S. Signal Corps, died at his residence in Washington, March 14, of softening of the brain. He had just returned from Omaha. Lieutenant Powell ranked third among the Signal Service lieutenants, according to seniority, and was the first officer appointed after competitive examination. He had a particular aptitude for indications work, and, as he was naturally bright, he made the best record on indications of any officer who has ever done the work. A few months ago he was sent to Omaha to take charge of the organization of a weather bureau for the Union Pacific Railroad.

COMMANDER EDWARD P. LULL, United States Navy, died at the naval station at Pensacola, March 5, at the age of 51 years. He was a native of Vermont, and in 1851 was appointed to the Naval Academy from Wisconsin. He was graduated in 1855, and up to the outbreak of the War he served on the *Congress* in the Mediterranean, and on the *Roanoke* of the home squadron, becoming master in 1858, and a lieutenant in 1860. He took part in the attack which the *Roanoke*, a steam frigate, made on the rebel forts at Hatteras Inlet in July, 1861, and in 1862 and 1863 was on duty at the Naval Academy. In 1862 he was commissioned lieutenant commander, and in the summer of 1864, on board the famous steamer *Brooklyn* of Farragut's busy fleet, he participated in the battle of Mobile Bay. He was honored by the command of the captured iron-clad *Tennessee*, which was attached to the Mississippi squadron, and joined in the bombardment of Fort Morgan in August, 1864. In 1866 he was on the *Swatara* of the West India squadron, and from 1867 to 1869 was at the Naval Academy. In 1870 he was commissioned commander, and in the following year commanded the store-ship *Guard*. In 1872 he was employed in the Bureau of Yards and Docks, in 1873, and '74 at the torpedo station, and in the two years following was Hydrographic Inspector of the Coast Survey.

HON. EDWARD BREITUNG, one of the pioneers in developing the iron mines of the Lake Superior Region, died at Eastman, Ga., March 3, aged 56 years. He was born and educated in Saxe-Meiningen, Germany, but came to this country when 19 years old, and settled in Detroit, Mich. In 1855 he went to the Lake Superior Region and opened a store in Marquette, then only a village. Soon after this he commenced exploring and buying and selling mineral lands. He remained in Marquette for four years, and in 1859 went to Negaunee, where he has since resided. Here he engaged in mercantile business, and also associated himself with Israel B. Case, and they ran the Pioneer Furnace under contract. In 1864 he sold out his business, and gave his entire attention to mining and mining interests. During the winter of 1864-1865 he began to open up and develop the Washington Mine, and in 1870 he began to open up the Negaunee hematite range. No one believed he would find merchantable ore there, and all thought the venture a foolish one. But he had confidence in his own judgment, and future developments have fully proved that it was sound. In the fall of 1871 he began to develop the famous Republic Mine. In 1873 he commenced explorations on the Menominee Range and continued them for three years. Here again everybody believed that he had embarked in a profitless venture, but, as before, the issue verified the correctness of his opinion. The immense amount of ore taken out of the mines on that range fully justifies the faith he had in that section of the Lake Superior iron field. In 1882 and 1883 he became interested in the Vermilion Iron Range, in Minnesota, where once again the investment that he made proved highly profitable. Mr. Breitung leaves a large fortune, the result of his successful mining ventures. He represented the Marquette District in Congress for four years.

CAPTAIN JAMES BUCHANAN EADS died at Nassau, New Providence, March 8, aged 66 years. He had been ill for some time, and had gone to Nassau with the hope of improving his health, but an attack of pneumonia added to the complications of his disease and carried him suddenly away.

Captain Eads was a native of Lawrenceburg, Ind., where he was born on May 23, 1820. He early evinced a love of mechanics, and when 8 years old watched with the greatest interest all machinery to which he had access. At the age of 10 his father, who had removed to Louisville, fitted him up a workshop of his own, and the boy constructed models of saw mills, fire engines, steamboats and other machines. In 1833 the family removed to St. Louis, but were reduced to poverty by the burning of the steamboat on which the father's property had been shipped. Young Eads began life in St. Louis by selling apples on the street, but soon obtained a place as clerk in a store, and in 1839 he secured a position as purser of a Mississippi steamboat. While acting in this capacity he took every opportunity to pursue his mechanical studies and to acquire a complete knowledge of the great river, which he was afterward to turn to so good an account.

In 1842 Captain Eads constructed a diving-bell boat to recover the cargoes of sunken steamers. It was his first invention of practical benefit, and was soon followed by a boat of larger tonnage, provided with machinery for pumping out the sand and water of sunken vessels, and lifting the entire hull and cargo. A company was formed to utilize this invention, and many valuable steamers were raised and floated by this method. It was while engaged in this wrecking business that he gained a thorough knowledge of the laws which control the flow of silt-bearing rivers, and he was able to say of the Mississippi a few years afterward, that there was not a stretch in its bed 50 miles long, between St. Louis and New Orleans, in which he had not stood on the bottom of the stream beneath the shelter of a diving bell. In 1845 he sold his interest in this company and established in St. Louis the first glass-ware manufactory west of the Ohio River. This enterprise failed, and he returned to the business of raising steamers, removing obstructions from the channel, and improving the harbor of St. Louis, a business which in the next ten years produced him a fortune of some half a million dollars.

In 1856 Mr. Eads made a proposition to Congress to keep the channels of the Mississippi, Missouri, Ohio and Arkansas rivers free of snags, wrecks and other obstructions, but his plan failed for want of action by the Senate. His work on this plan, however, was not forgotten, and early in the war, when it was decided that operations in the West must follow the line of the Mississippi, he was asked to prepare plans for gunboats to be used on that river and its tributaries. He designed seven iron-clad gunboats and took a contract to build them, completing the work in a little over two months, near the end of 1861. In 1862 he was commissioned to build six more armored iron gunboats, four of which were much larger than any of the preceding ones. While these were under way he also had the construction of four heavy mortar boats and seven "tin-clad" or musket-proof boats. The good service which these vessels did during the war in assisting the operations of the Army in securing control of the river is a matter of history.

After the close of the war, Captain Eads undertook the construction of the great bridge over the Mississippi at St. Louis. This bridge, with its central steel arch of 525 ft. span, and the side arches of 502 ft. each, has often been described, and much has been written of the difficulties encountered in the erection of its piers, and in the sinking of the caissons on which they stand. It was finally completed and opened for traffic July 4, 1874, nearly seven years after the work was first begun.

Upon the completion of the St. Louis Bridge, he

began to press his plans for deepening the mouth of the Mississippi by jetties, a plan in which he was opposed by nearly all the United States engineers, a commission of seven having reported strongly against it. This commission proposed to avoid the bars by constructing a canal from Fort St. Philip to Breton Bay. Mr. Eads' plan was to make the river itself deepen a channel through the bars, and he offered to do the work at his own expense, and wait for his pay until he demonstrated its success. He finally secured permission on those conditions to attempt the improvement of the South Pass, the smallest of the three, the depth on the bar of which was only 8 ft. Captain Eads at once began the work of contracting the width of the current by means of jetties, thus increasing its rapidity and power of wearing away its bed. In four years the success of the jetty system had been demonstrated, a maximum depth of 30 ft. having been secured throughout the jetty channel. Mr. Eads was paid the sum agreed upon by the Government, $5,125,000 in all, part of which had been paid in instalments. The current of the river has maintained its depth ever since, and the cost of the jetties was about half that estimated for the construction of the proposed canal.

Besides these works, Mr. Eads, at the request of the governments and individuals particularly interested, examined and reported upon the bar at the mouth of the St. John's River, Florida, the improvement of the Sacramento River, the improvement of the harbor of Toronto, the improvement of the port of Vera Cruz, the improvement of the harbor of Tampico, the improvement of the harbor of Galveston, and the estuary and port of the Mersey, England. He was President of the St. Louis Academy of Science for two terms, and made an inaugural address in which was embodied a review of the recent achievements of science, and, in another, the present knowledge of the laws of light. In 1881 he made an extemporary address before the British Association at York upon the improvement of the Mississippi, and also upon the Tehuantepec Ship Canal which were, by unanimous vote, ordered to be embodied in its report of the proceedings, and in June, 1881, he was awarded the Albert Medal of the British Society of Arts, in token of its appreciation of the services he had rendered to the science of engineering—he being the first American upon whom this medal had been conferred. He was also for a year Vice-President of the American Society of Civil Engineers.

Captain Eads was not a man to rest quietly on the reputation of his past successes, however, and he soon became interested in a new project, the construction of a ship railroad from the Atlantic to the Pacific, across the Isthmus of Tehuantepec. He spent much time in demonstrating the practicability of his plan, by which ships were to be transported across in cars, loaded in cribs made especially for the purpose. He argued that such a railroad could be built wherever a canal could, at one-half the cost of the canal with locks, or one-quarter the cost of one at tide-level. He claimed that a ship railroad could be maintained for less than a canal, and that his plan, if carried out would, both by its method and location, be of greater service to commerce than either the Panama or the Nicaragua canals.

Captain Eads obtained a concession for the building of his ship railroad from the Mexican Government, and secured the organization of a company. He was, however, unsuccessful in his attempts to persuade the United States Government to undertake the work or to guarantee interest on its cost. A bill to incorporate this company passed the United States Senate during the session just closed, but failed to pass the House.

Captain Eads was married in 1845 to Martha N. Dillon, daughter of Patrick M. Dillon, of St. Louis. His wife died in 1852. He was again married to Mrs. Eunice S. Eads, who survives him. He had five daughters, three of whom married, respectively, John A. Ubsdell, of New York; Estil McHenry, Assistant Postmaster, of St. Louis, and James F. Howe, of St. Louis, Secretary and Treasurer of the Wabash Western Company. Capt. Eads was granted the degree of LL.D. by the Missouri State University. He was identified with St. Louis business from the time of his arrival there as a boy, and always considered himself a citizen of that city, although his Tehuantepec project had led him to spend much timc in the East for two or three years past.

Contributions.

Mason and Dixon's Line.

Ediior of the Railroad and Engineering Journal:

IN the opening paragraph of your article upon Geodetic Work in the United States, in your March issue, I think you somewhat mistake the popular idea of Mason and Dixon's Line—that it "was the northern limit of slavery established by the Missouri Compromise in 1820." The popular belief was that this line was the northern limit of slavery east of the Ohio River, which was in accordance with the facts, so far as Mason and Dixon's Line forms the south boundary of Pennsylvania. It was known as such before the days of the Missouri Compromise, and was fixed in the public mind and made historical by the political speeches of that fervid period.

As a matter of professional interest, I will state that the original Field-book and Journal of Mason and Dixon is deposited in the library of the Pennsylvania Historical Society in Pennsylvania in Philadelphia. It is a volume of foolscap of over 300 pages, and contains all their notes and computations. Each page is signed by both astronomers. H. W. CLARK.

SYRACUSE, March 5, 1887.

The Forney Car-Seat.

To the Editor of the Railroad and Engineering Journal:

Your last issue contains a description and illustration of the "Forney car seat," and claiming for it merits over the ordinary car seats. The "Forney seat" is undoubtedly more comfortable than the ordinary car seat, but the "Forney back" is far from comfortable. I have sat in the Forney seats many hours, riding on the New York Central Railroad, and found the concavely shaped backs so tormenting that I prefer an ordinary car seat. For hunchbacked, or old, stooping persons the "Forney back" may do; but not for a naturally straight spine. I believe that the back should neither be concave nor convex, but it should be straight, properly inclined, and not so high as to compel taking off one's hat. I have heard the same complaint from other travelers with straight spines.

TRAVELER.

[The criticism of "Traveler" of the seats referred to is, to some extent, a just one. In designing them the mistake was made of giving the backs *too much* curvature. This defect has been remedied in seats made since those referred to were put in the New York Central cars, and the same change can easily be made in them by a little alteration of the upholstering. To make the backs straight, as proposed, would, however, defeat one of the objects aimed at in this form of seat, which is to give support to the lumbar region of the backs of passengers. The backs of all drawing-room car chairs and seats in sleeping cars are now made curved, and in European railway carriages that form is universally adopted.

There is a very great difference of opinion with reference to the most comfortable length for the backs of car

seats. In drawing-room and sleeping cars high backs are now universally demanded, whereas some passengers, like our correspondent, object to them in ordinary cars. Probably for local travel low backs are preferable; but for long journeys a support for a passenger's head is certainly very grateful.—EDITOR RAILROAD AND ENGINEERING JOURNAL.]

THE GEODETIC WORK IN THE UNITED STATES.

II.—BORDEN'S SURVEY OF MASSACHUSETTS.

BY PROF. J. HOWARD GORE.

WHILE the primary object of this survey was simply to secure an accurate map of Massachusetts, the trigonometric part of it was so elaborately conceived and so carefully executed that the results have been regarded as suitable for geodetic data. This work was the carrying out of two resolves of the General Court of Massachusetts during the session of 1829-30, one requiring each town in the Commonwealth to forward to the office of the Secretary of State accurate maps of its territory on a scale of 100 rods to an inch, and the other empowering the Governor to appoint a surveyor with assistants to make a trigonometrical survey of the State, accompanied by astronomical observations.

Robert Treat Paine, of Boston, was selected Chief Engineer with Mr. Stevens, of Newport, as Assistant, and Simeon Borden was ordered to repair the instruments loaned by the United States Coast Survey, and to construct the base apparatus.

The astronomical observations and transfer of chronometers for the determination of differences of longitude were commenced by Mr. Paine in the spring of 1831, together with the triangulation by Mr. Stevens, assisted by Borden. In 1834 Stevens resigned, when the trigonometric work fell to Borden, and in 1838 Paine retired, after which Borden was placed in charge of the entire survey, a position he held until its completion.

The base apparatus was modeled somewhat after the one first used by Colby, in 1827, in the measurement of the Lough Foyle base. It was 50 ft. long, consisting of two rods ⅜ in. in diameter, one of steel and the other of brass. Each rod was composed of four nearly equal parts, joined end to end by coupling boxes so made that the ends of two parts could be brought into perfect contact and held in that position. The attachments of the rods were of the same metal as the rods themselves. They were supported within a tin tnbe, larger in the middle than at the ends, by nineteen cast-iron stirrups, each of which was secured by five screws to keep them in a single plane and the rods straight when in place. Near the center of each sheet of tin forming the tube was soldered a flange of tin 1 in. deep, which served to strengthen the tube and prevent it from collapsing while in use; the supports were placed near these flanges. The tube was 49 ft. long, the four pieces of which it was made being attached to one another by small screw-bolts passing through strong brass flanges that were fastened to the end of each section. These flanges were of sufficient strength and size to allow the two end ones to serve as bearings to rest in the Y's of the trestles. The ends of the tube were closed with cast iron pieces with holes in them, through which the rods passed. To the ends of the rods transverse arms were attached; one end of each arm carried a small silver disc with cross-lines on its horizontal face, the intersections of the lines marking the ends of the measure. By making the distances from this intersection to the attachment to each of the rods proportional to the coefficient of expansion of each, the intersection should remain invariable at all temperatures—a principle beautiful in theory but unsatisfactory in practice. The failure of this principle, known as that of compensation, may be owing to uncertainties in the assumed coefficients of the particular rods in use, the inconstancy of the adopted coefficient, ignorance as to the results of molecular change during fluctuations of temperature, or to mechanical inability to correctly secure the proper ratio of the lever arms.

The tube was supported upon two tripods, carefully and substantially made, the heads having horizontal and vertical motions, by means of thumb-screws. The microscopes were compound with a focal length of 1⅝ in.; these were provided with trestles similar to the others. The line, situated in the Connecticut Valley above Northampton, was aligned, using for the purpose the theodolite that was afterward employed in placing the tubes in line during the measurement.

The termini of the base were marked with cross-lines upon copper bolts of about ¾ in. in diameter; these were driven firmly into holes drilled for the purpose in large stones, and imbedded in the earth about 18 in. beneath the surface.

In measuring, the cross-wire of one of the microscopes was adjusted over the mark on one of the terminal monuments; the tube was then put on the trestles previously placed in position and moved laterally until in line, and longitudinally until the mark on the disc attached to one end of the rods was in coincidence with the cross-wires of the microscope. The other microscope was then adjusted directly over the disc on the forward end, after which the tube was carried forward and so placed that the rear end would be under the second microscope, and so on, the whole work requiring the services of eight men. The inclination and number of tubes were recorded. Under the intersection of the cross-wires of the microscope that marked the last of each 20 tubes, a piece of brass wire was put in a wooden plug driven in the ground. The end of each day's work was similarly fixed.

The line was measured twice and the differences in the distances between each pair of marks were noted; the maximum difference was 0.828 in. and the minimum 0.02 in., with 3.523 in. as the sum, while, after correcting for inclination, the difference in the two measures was only 0.237 in., or 1 : 1,975,176 in a line 39,009.73 ft., or 7.3882 miles long, when reduced to sea-level and referred to Hassler's 82 in. Troughton scale at 62° F. The elevation above sea level was found trigonometrically, giving the northern end 49.55 ft. higher than the southern, while, by computing the difference in the height of the two ends of each tube from its known length and the observed inclination, and taking the algebraic sum of these differences, the northern end was 50.43 ft. higher than the southern end. The latitude and longitude of both ends of the base were carefully determined, the former from a large number of observations on circumpolar stars, and the latter by transfers of chronometers.

In the triangulation a repeating theodolite with a 12 in. circle and telescope of 46 in. focal-length was used.

While observing, the instrument was protected by a circular tent having the upper portion of each side provided with flaps, so as to be opened or closed when necessary. Artificial signals were built at every station; these consisted of tripods with a center-pole pivoted at the point of attachment to the tripod. In some cases these center-poles were as much as 80 ft. high, when it was found necessary to guy them with wire in four directions. To make the signal visible at a great distance a very ingenious device was adopted. A bag with both ends open, made of cotton, was kept inflated by having sewn within it two barrel hoops; the whole was placed around the center-pole, the ends gathered in and firmly attached to the pole. This may have suggested the barrel that was afterward used by the Coast Survey on reconnoissance and secondary triangulation. The center of the station was marked like the ends of the base, its position having been determined by the aid of two transits placed approximately at right angles to one another. When a station was occupied the center-pole was tilted over, so that the lo ver end would be out of the way, and the observing tent suspended from the tripod.

The time spent at each station varied from one to twelve days, care being taken to observe, as far as possible, at times when the atmosphere and underlying earth between the observing and observed stations were nearly of the same temperature. Azimuth observations were made at two points within each section 50 miles square. The formulæ used in computing geographical positions were those of Oriani, involving an "elliptic spheroid," first published in 1821.

He computed the lengths of eight meridional arcs, and from each deduced the length of a degree; this varied from 364,336.76 ft. to 364,447.68 ft., with a mean of 364,392 ft. in lat. 42° 4′ 2.48″, or 364,356 ft. in lat. 42° 21′ 40″, which is the latitude of the State House. He also took the longitude of the State House for an initial point, and computed the value of a degree perpendicular to a meridian. In this Paine's longitude determinations were used, and in computing a relative weight, proportional to the polar angle subtended, was given to each arc employed, resulting in 365,747 ft. for a degree as the mean of 10 arcs.

With the data so obtained he determined the earth's elements, which, by comparison with those now quite generally credited, reveal agreements that one could hardly expect when one realizes that this work was done during the infancy of geodesy in this country.

	Borden.	Bessel.	Clarke.
1° of a meridian lat. 42° 21′ 30″ in feet............	364,356	364,403	364,433
1° perpendicular to a meridian 42° 21′ 32″ in feet.	365,724	365,740	365,542
Ellipticity..........................	1:292	1:299	1:293

One is naturally tempted to think that the close agreement between Borden's and Clarke's values is due to chance or accidental compensation of errors, but a crucial test has been applied to Borden's linear measures by the occupation of many of his stations by the Coast and Geodetic Survey, and the subsequent computation of distances that he had determined. The discrepancy between the two results varies from 16 in. to 0.8 in. in a mile, with 6 in. as the mean, or 1 : 10,560; also in the Nantucket arc the Geodetic Survey computed the length of a degree from several small arcs; the nearest mean latitude to Borden's was lat. 41° 36′ 34″, at which point a degree was found to be 364,452 ft., being about 100 ft. longer than Borden's degree at this point. Clarke's spheroid gives for this latitude a degree about 85 ft. longer than Borden found.

We are indebted to Borden for methods rather than for results; his observing tent, signal and care in selecting times for reading angles have became leading features in all geodetic work done in this country since his time. The theodolite with a high supporting standard and repeating angles, copied from the Coast Survey and Ordnance Survey, have long since been abandoned, together with the compensating base apparatus. It has also been found that the flexure in so long a bar would introduce errors of a serious character, so that now we never find an apparatus of more than half the length of Borden's, while many are no more than one-fourth as long.

It is believed that in no country was the first trigonometric geodetic work so successfully performed as was this, America's first contribution.

ROAD BRIDGE OVER THE RIVER TONE AT MAEBASHI, GUMMAKEN, JAPAN.

BY M. OTAGAWA, M. E., TOKYO.

During the year 1884, when the main trunk line of railroad through central Japan was to be constructed along the Nakasendo, the Tokyo & Takasaki line was branched to Maebashi, which is the centre of the silk districts in Gummaken, and a road bridge over the River Tone (one of the largest rivers in Japan) had to be constructed at the entrance of the city. Till that time the whole traffic was carried on an old and fragile wooden bridge, a little above the new site, and crossing the river at so low a level that the gradients of the road on both sides were too steep for carriages, and the bridge was often damaged by floods. These inconveniences were much more marked when the railroad reached Maebashi, and caused both the government and people to take some active steps towards the construction of a new bridge. The capital, however, was very limited, being 26,000 yen (about $21,300) for the whole work, including approaches of three-quarters of a mile on both sides of the bridge. Of this fund 15,000 yen came from the local land-tax of Gummaken, and the remaining 11,000 yen was contributed by the inhabitants of Maebashi.

In common with other Japanese rivers in the dry season, the water of the River Tone is very low; but in summer and autumn it is often visited by fearful floods. The bridge site was chosen at the narrowest part of the river, which is best protected in the up-stream by boulders of gigantic size. The very existence of these stones sufficiently proclaims the rapidity of the stream in times of freshets. As there were no people living near the site, information as to the highest flood level could not be obtained, but it was calculated to be 24 ft. above ordinary water level, from the data obtained above and below the site.

The total length of the new bridge is 600 ft., of which 180 ft. consists of two spans of Howe truss in timber; the remaining 420 of 10 spans of beam bridge of the Japanese type with some modifications, each span being 42 ft. The camber of the bridge is 4 ft 3 in., and the width is 24 ft., the formation level being 40 ft. above ordinary water level.

The eastern abutment is brickwork on a concrete foundation, and the western is rubble work on a foundation of piles. There are two cast-iron piers and 10 wooden ones. The river piers are each formed of two columns, placed 22 ft. 7 in. apart from center to center. These columns are composed of cast-iron cylinders, the metal being ¾ in. thick, and are 3 ft. in diameter and in 6-ft. lengths, jointed by 12 1-in. bolts through inside flanges. For 12 ft. at the base the cylinders are 4 ft. in diameter. These columns are filled with concrete and firmly braced.

The superstructure is formed of Howe timber truss continuous over two spans. The truss is 7 ft. 3 in. high between the centers of the booms, which are 16 x 12 in. The span is 90 ft., and is divided into 20 bays, each 4 ft. 6 in. The cross-girders, 12 x 9½ in., are placed on the bottom booms of the truss at intervals of 4 ft. 6 in. The joists, 6 in. square (and 6 x 10 in. at center where planks are jointed), are placed in five rows upon the cross-girders. Upon these timbers is laid transversely 3½ in. planking. These two spans extend over 180 ft.

For the remaining 420 ft., for which the bed is dry in ordinary weather, a simple though less satisfactory design had to suffice, as the funds were so limited; so that the beam bridge was constructed. Here the piers consist of five wooden piles of 15 in. diameter, with butt ends braced and stiffened by crib-work at the bottom. The cantilever beams and longitudinal stringers, 16 in. square, are placed in five rows upon the cross-beams of the pier. Upon the stringers there is laid transversely 3½ in. planking. The parapet railing for this part of the bridge consists of castings with wooden posts fixed to the exterior stringers at intervals of 6 ft.

For the purpose of facilitating the transportation of the building materials to the bridge-site, and giving accommodation to the public, the road on one side from the railroad station and on the other from the southwestern corner of the city of Moebashi to the bridge was constructed, and a temporary pontoon bridge made a little below the site. The road is a gravel road, 30 ft. in width.

The timbers were obtained on the surrounding mountains at distances from 2 to 40 miles. The cast-iron piers, tie-rods and bolts were made by Masuda & Co. at Kawaguchi, and the hand-rails by Ojima & Co. at Takasaki. The bricks and cement were brought from Tokyo, while quick-lime of the best quality was cheaply obtained from a quarry in the vicinity. The advantage derived from the new railroad for the transportation of these materials was of no small value.

The building materials having arrived at the site when the river-bed became dry in October, 1886, the excavations for the abutments were commenced. The materials to be excavated for the eastern abutment consisted of strata of hard clay and sand, with vegetable earth. Thus, the material being compact, the excavation was finished with a slope of 1 in 12, and fortunately no water guttered, so that much expense was saved on this abutment. The excavation extended downwards until a bed of boulders was reached. On this bed a concrete foundation, surmounted by foundation courses of stone, was laid. The brickwork was constructed upon this foundation. The western abutment was constructed with rubble stones from the river, laid upon a foundation of piles.

The excavation for No. 1 pier was done by sinking a cylindrical crib, 6 ft. in diameter, of sheet piling 3½ in. thick, the outside of the crib being puddled with clay. Inside the crib water accumulated very rapidly, and had to be pumped out by a centrifugal pump, worked by a steam-engine and exhausting 1,800 gallons of still water per minute. At the same time gravel inside the crib was cleared out. The excavation was continued in this way to a depth of 12 ft. below the river-bed, when the accumulation of water became so rapid that there was scarcely any diminution even when the engine was working at full speed. The pressure of water and gravel on the outside of the cylindrical crib was so very great as to cause it to distort into a shape slightly elliptical, having the major axis 7 in. longer than the minor. When this occurred a layer of coarse gravel was reached, so that excavation was stopped and concrete placed for the foundation. The cast iron piers were then put in position, and filled with concrete inside and packed at the foundation with concrete between the outside and the crib. The leveling was now done, and the exact lengths of the topmost portion of the cylinders ascertained. The piers were erected by means of derricks and hemp ropes, which are the only machinery generally used by Japanese coolies. The sinking and erection of pier No. 2 were carried out in the same way as those of No. 1, excepting that puddle was not required outside the crib, the river-bed being dry in this part during winter.

While the piers were being erected, all the necessary timbers and suspension-rods were prepared, and framing of the trusses commenced, in order that all the parts of the work might progress to completion with as little delay as possible. As the formation level of the bridge is 40 ft. above ordinary water level, and the stream so rapid, being subject to violent floods in summer, a staging for the superstructure could not be easily constructed without a great expense; so that the trusses were launched into their places without any scaffolding. Of the continuous truss of two spans only one-half at first were framed, and, launched through a little less than the half-length of the framed portion, the other half was acting as the counterbalancing weight; then the remaining portion was hauled over. The launching was performed by sliding the bottom boom upon rollers by means of tall derricks and hemp ropes, so as not to touch the top of the cast iron piers while being hauled over. This was very successfully done, notwithstanding the deficiency of machinery and the fact that the work was not familiar to our workmen, so that directions had to be constantly given.

As soon as the trusses were launched over, they were set and fitted to the proper position, both in direction and level, and the superstructure was at once completed for this portion of the bridge.

While this half of the bridge was in progress, the remaining portion, consisting of a beam bridge, was being constructed, in order to push the whole work to completion with the least delay. As the river-bed at the wooden piers was dry, excavation was done with the utmost ease, except at the three piers towards the iron one, where some hand-pumps and screw-pumps were required for pumping out water. Wooden piers were here erected by means of derricks and hemp ropes, and they were braced and stiffened by crib-works filled with large stones and mortar. The beams and struts were also put in position by means of the same simple contrivance; then the planking and the hand-rails were added. Lastly, the fenders for the piers were erected in their positions. Abutments

and piers were afterwards protected by fascine-works.

The bridge was thrown open for public traffic on June 30, 1885. On the day following it was visited by a sudden flood, which rose 18 ft. above ordinary water level. This flood destroyed the fragile old bridge above the new site, but caused no damage to the new work, showing the urgent necessity for the latter.

CLASSIFICATION OF IRON AND STEEL.

THE following classification and definition of the terms "iron" and "steel" and their varieties was given by Mr. William Kent in 1883, in his expert testimony in behalf of defendant in the case of Cooper, Hewitt & Co. *vs.* Pennsylvania Steel Company, a suit brought to determine the validity of the U. S. patents of Messrs. E. & P. Martin on the open-hearth steel process. The suit referred to was decided in favor of the defendants on the technical ground that it had not been begun within the limit of time required by law, and the question of the original validity of the patents was left undecided. A few copies of the printed testimony were privately distributed, but with this exception the classification, which is here given, has never heretofore been published.

Question 36. Please give the technical meaning or definition of, and where there is any difference between the two, the commercial designation of iron; cast-iron; wrought-iron; cast steel; steel; crucible steel; Bessemer steel; open-hearth steel.

A. *Iron* is a metal which is not found chemically pure either in nature or in commerce, but is always associated with one or more metallic or non-metallic elements. The word iron when standing alone, both in commerce and in metallurgy, is used as a generic term, to designate a great variety of compounds or alloys of the element iron with other elements, but, generally speaking, it is confined to mean such compounds as are used for the purposes of construction, and does not include generally those compounds of iron with other elements which are found in a crude state in nature, and which are usually called iron ores.

The words iron ores are used to designate those compounds of iron with oxygen, of greater or less purity, (that is, associated with greater or less quantities of other elements than oxygen), which are dug out of the ground, and which constitute the original raw material from which all kinds of commercial irons and steels are derived.

Iron ores are thus always oxides of iron, but there are also other oxides of iron which are not called ores, such as iron-rust and iron-scale, both of which are formed by the oxidation of some form or other of commercial irons. Although these oxides of iron are not called ores, they may nevertheless be used like ores, as the raw materials from which commercial irons are derived by various processes; and whenever these oxides which are not called ores are used in any metallurgical process, whether as raw materials or as additions to a bath of other raw materials, they perform the same function as iron ores do.

I have stated that iron is a generic term, which is used to include a great variety of commercial products in which the metallic element, iron, is the chief component part. This includes several materials, in the name of which the word iron itself may not appear, such as steel, muck-bar, spiegeleisen, etc. Whenever, therefore, it is necessary to designate one particular variety of iron from another, some special designation other than the word iron standing by itself must be used—either iron prefixed by some adjective, as cast-iron, wrought-iron, or some other word, such as muck-bar or puddled balls or blooms.

In order to particularly define the various kinds of commercial irons which are mentioned in the question, I think it will be necessary for me to begin with a sort of classification dividing the generic term iron into its several species and varieties. Several methods of division or classification have been adopted by various technical writers. Some of these make the greater or less content of carbon the principle upon which the classification is based. Others base the subdivision upon the differences of the furnace or vessel or metallurgical process by which the finished material is obtained. Still others make a general division of the generic term iron into two classes, based upon the difference of condition in which the final product is obtained, and then subdivide these two classes into others. The latter method of classification is the one which I conceive to be the clearest, and the one which I shall now adopt.

I thus divide all the commercial products which may be included under the generic term iron into—1st, irons which are cast from a fluid mass; and, 2nd, irons which are made up from pasty masses.

Beginning with the irons which are cast from fluid masses, these may be subdivided into two classes or subdivisions: 1st, those which are malleable, that is, those which may be forged; 2d, those which are not malleable. Of the irons which are included under the second subdivision, that is, those which are cast from fluid masses and which are not malleable, I know of but one species, which is generally called *cast-iron*, but which is also called pig-iron, the word pig-iron being used chiefly to designate the shape in which this cast-iron is usually obtained. This is the commercial metal which is obtained by smelting ores in the blast-furnace. It is generally the most impure of all the commercial metals included under the generic term iron, and may contain not over 80 or 90 per cent. of pure metallic iron. It generally contains somewhere about 4 per cent. of carbon; it may contain varying proportions of silicon, of phosphorus, of sulphur, of manganese, of chromium, of titanium or other elements. Although some of these elements may be contained in only small traces, others may be in considerable quantities. Thus there have been made pig-irons containing more than 2 per cent. of phosphorus, as much as 8 per cent. of silicon, and as much as 20 per cent. of manganese. Frequently the pig-irons which contain considerable quantities of these various elements are designated by various adjectives qualifying them, such as gray pig-iron, white pig-iron, phosphoriferous pig-iron, and manganiferous pig-iron.

Passing now to the first subdivision of the irons which are cast from fluid masses, that is, those which are malleable, these may be further subdivided into two divisions or species, namely: 1st, the product which is generally known in the United States as malleable iron, also as malleable cast-iron, or as malleableized cast-iron; 2d, the various forms of cast-steel. (I must here explain that in England and sometimes in this country the words malleable iron are also used to designate another kind of a product, namely: what is ordinarily called in the United States wrought-iron.)

Tnis malleable iron, or malleable cast-iron, or mallea-

bleized cast-iron is made by removing all or a portion of the carbon from cast or pig-iron while the latter remains in a solid state. This removal is generally accomplished by heating or annealing, for a considerable period of time in a closed box, the cast-iron surrounded by some form of oxide of iron.

The second division or species of those irons which are cast from fluid masses, and which are malleable, are the cast steels of commerce. These cast-steels may generally be defined by the classification I have already given, that is, they are malleable compounds of iron which are cast from fluid masses. The one feature which distinguishes these cast steels chemically from cast-irons which are cast from fluid masses, but are not malleable, that is, which distinguishes them from pig-iron, is that they contain smaller quantities of carbon than pig-iron contains, and they also usually contain smaller quantities of those other elements than carbon, which are contained in pig-iron.

These cast steels are known by various names in commerce according to the vessel or furnace in which they are produced, such as crucible steel, Bessemer steel, and open-hearth steel. The difference between these steels does not necessarily extend further than to the furnace or vessel in which they may be produced; there is no necessary chemical or mechanical distinction between them, for cast steels may be and are produced by either one of these processes, which cannot be distinguished either chemically or mechanically from similar steels which are produced by either of the other two processes.

I will describe later in this answer the methods by which crucible, Bessemer or open-hearth steels may be produced, but will suspend this portion of my answer until after I have defined those irons which are not cast from fluid masses, but which are welded from pasty masses.

The irons which are welded from pasty masses may be subdivided into two classes: 1st, wrought or welded irons; 2d, wrought or welded steels. The wrought-irons may again be subdivided into different varieties of wrought-iron according to the furnace in which, or the process by which, they may be obtained. I subdivide them into two classes: 1st, those obtained by direct processes from iron ore or from iron scale; 2d, those which are obtained by indirect processes or by the refining of pig-iron. The wrought-irons obtained by the indirect and by the direct processes are not distinguishable from each other by mechanical or chemical means, but are only distinguished as regards the processes by which they may be obtained. The general method of obtaining wrought-irons by direct process is the reduction of the ore to the metallic state by carbon or carbonic-oxide gas, and heating the reduced ore to the welding-point and welding together the mass into the finished product. This product, before any subsequent operations are performed upon it, is generally known as a wrought-iron bloom. There are many different methods of conducting this process, such as the Catalan process, the Siemens direct process, Chenot process, etc., which I need not further refer to, as their general method as well as their product is the same.

If in this direct process there is an excess of fuel used and a temperature higher than the welding temperature, in addition to the reduction of the iron of the ore to the metallic stage: another feature or metallurgic process may be accomplished, namely, the absorption by the metallic iron of other substances in greater or less quantity, as carbon, silicon, etc. If the absorption of such substances, especially the carbon, is to such a degree that the finished product is much harder than wrought-iron, but still retains the pasty condition during the whole time it is in the furnace, the resulting product may then be known as steel, or wrought or welded steel, instead of wrought-iron.

If the absorption of carbon, due to the high temperature and the excess of carbon present, it is so great that the metal becomes liquid in the furnace and is cast from this fluid mass, the resulting product would then be known either as cast or pig-iron, or as cast-steel, according to the greater or less percentage of carbon it contained.

The direct process, therefore, of producing at one operation from the ore, wrought-iron, wrought-steel, cast-steel, or pig-iron, may be the same kind of a process, differing only in the greater or less absorption of carbon during the operation. If the absorption is the least possible, the product is wrought-iron; if it is a little greater, but the product still retains the pasty condition while in the furnace, the product is wrought-steel; if the absorption is still greater, so that the metal becomes fluid at the last stage of the process, the product is cast-steel or pig-iron, according to the amount of carbon contained in the finished product.

Wrought-iron may also be produced, as I have stated, by an indirect process, that is, from cast or pig-iron, by the removal therefrom of the carbon and other elements to a greater or less extent. This removal of the carbon, or what is called refining, may be carried on in different kinds of furnaces, such as the Lancashire hearth and the puddling-furnace.

I have stated in a previous portion of this answer that malleable or malleableized cast-iron is cast or pig-iron which has had the carbon taken out of it by heating or annealing in closed boxes in presence of oxide of iron. The oxygen in the oxide of iron in this case is the agent of refining, that is, of the removal of carbon. In all refining operations for the removal of carbon from pig-iron, or from steel, or from any form of iron whatever, the agent of refining is oxygen. The oxygen unites with the carbon and forms carbonic-oxide gas, which escapes.

This oxygen may be derived from oxides of iron, such as iron ore, iron scale or iron rust, from the atmosphere, from carbonic-acid gas, or from oxides of other metals than iron. In whatever form the oxygen is applied, whether to iron in the solid state, as in the making of malleablized cast-iron, or in any of the various operations of iron or steel manufacture in which carbon is removed from the metal, the operation is the same, namely, the formation of carbonic-oxide gas by the union of carbon and oxygen.

In the puddling process, which is the process most generally used for the production of wrought-iron from pig-iron, the carbon is burnt out of the pig-iron by oxygen, which is derived both from the excess of atmospheric air or of carbonic acid gas in the flame which traverses the surface of the metal, and from the ore and scale by which the bed of the furnace may be lined, or which may be added to the bath during the operation. In the refining process, which is used sometimes as a preliminary stage to the puddling process known as the "refinery" or the "run out" process, part of the carbon and the silicon is burned out by the oxygen of atmospheric air, which is projected downward into the bath of metal.

I have now defined the wrought irons which are welded up from pasty masses, and which may be produced

in two ways: 1st, direct from the ore by one form or other of "direct process:" 2d, indirectly from pig-iron by some form or other of refinery process.

I have also shown that a wrought-steel may be formed by the carbonization of the metal in the direct process. A wrought-steel may also be formed in the indirect or refinery process, puddling or other, by arresting the decarbonization before the carbon is burned out to the degree that it is in producing wrought-iron; or, in the same process, by decarbonizing to the fullest extent, and then recarbonizing by an addition of some form of iron or steel which contains more carbon than wrought-iron. There is still a third method of producing wrought-steel known as the cementation process, which concists in taking wrought-iron, whether produced by the direct or indirect process, by adding carbon to such wrought-iron while it remains in the solid state; this is the inverse of the process of making malleableized cast iron. It is generally performed by surrounding bars of wrought-iron by charcoal in a closed box or furnace and heating them together for a considerable period of time. If such heating is continued long enough the amount of absorption of carbon may be as much as 4 per cent., in which case the resulting product will have lost one of the distinguishing features of ordinary steel, namely, malleability, and becomes similar in its content of carbon, as well as its non-malleability, to cast or pig-iron. Steel made by cementation process is generally called blister or shear steel. Puddled steel is the product of the puddling-furnace when the puddling process is arrested before the decarbonization is completed, as for wrought-iron, or when it is so completed and the subsequent addition of a recarbonizer is made, the product in both cases being withdrawn from the puddling-furnace while in a pasty condition.

I now come to define and distinguish the cast-steels which I have already referred to, namely, crucible, Bessemer and open-hearth steels.

The finished products known by these names do not differ in quality, but only in the process by which they are obtained. The characteristics which they all hold are that they are malleable, are cast from fluid masses, and contain a smaller amount of impurities than cast or pig-iron. By impurities I mean carbon, silicon and other elements. They always do contain, however, a certain amount of these impurities, and they generally, though not necessarily, contain a larger amount of carbon than is found in wrought-iron.

In addition to the names crucible, open-hearth and Bessemer, by which these steels are designated they also have other names given to them to designate their quality as soft and hard steel, high and low carbon steels, or steels of various percentages of carbon.

The percentage of carbon in steel determines its hardness, and chiefly the purpose for which it may be used.

It is evident that as these steels contain always less carbon and other elements than are found in pig or cast-iron, and generally more carbon than is found in wrought-iron, they may be made either by refining or decarbonizing pig or other highly carbonized irons, or by adding carbon to the purer wrought irons, or by mixing and melting together irons containing respectively higher and lower percentages of carbon; or they may be made directly from the ore by deoxidizing such ore—that is, reducing it to the metallic state—and adding the requisite quantity of carbon, either from the fuel or from some carbonaceous substance added for the purpose, or from the addition of pig or other highly carbonized iron, or by any combination of any two or more of these methods of decarbonizing, deoxidizing, carbonizing or recarbonizing. In other words, beginning with pig or other iron containing a high percentage of carbon, and iron which may contain no carbon at all, and steel which contains more or less carbon, a cast steel containing any required percentage of carbon may be made by addition and subtraction, or mixing or diluting or combining in any form whatever two or more of these materials; or it may be made by beginning with pig or other highly carbonized iron, and burning out the carbon by oxygen derived from any source whatever, even by pure oxygen gas, as is mentioned in one of the patents of Messrs. Martin; but such cast-steel, however made, is cast from a fluid mass, and is not welded up from a pasty mass at the end of the operation.

Crucible steel is distinguished from Bessemer and open-hearth steel by its being made in a crucible or small pot, which is generally provided with a lid; a mixture of steel-making materials is made and placed in this crucible, and the whole is thoroughly melted, and poured into an ingot-mould. The mixture may be of various kinds and of various proportions. In this mixture may be used iron ore, pig-iron of various kinds, wrought-iron, steel of various kinds, and in general any of the products which are included under the generic term of iron, as well as other substances, such as charcoal, various carbonaceous matters, metallic manganese, or alloys of the same with one or more metals, and a vast variety of other substances. The operation of making crucible steel may be a refining process, in so far as pig-iron may be used as the principal raw material, which is decarbonized by the oxygen of the ore or other oxides placed in the crucible. It may be a reaction or mixing process, in so far as a mixture may be made of iron highly carbonized, and of one which contains little or no carbon. It may be a reduction and a carbonizing process, in so far as iron ore may be used as the principal material, which is deoxidized and carbonized by carbon or carbonaceous substances of which the crucible may be composed, or which may be added in the crucible. It may be a decarbonizing in combination with a recarbonizing process, as in the case in which pig or other highly carbonized iron is the principal component of the mixture which is decarbonized by the other components, such as oxides of iron or of manganese, wrought-iron, etc., and recarbonized by a subsequent addition of a recarbonizer before pouring. The crucible process is thus susceptible of a great variety of modifications.

The Bessemer process for the manufacture of steel has for its chief feature the refining or decarbonization of pig-iron in the vessel known as the Bessemer converter by the oxygen of atmospheric air, which is generally introduced at the bottom, or below the surface of the bath of melted cast-iron, but which may be introduced downwards, from the surface. The carbon is burned out of the pig-iron either to the degree required to form steel, and then the metallic bath is poured into ingots, or the carbon may be entirely burned out, and the bath recarbonized to the required degree by an addition of a quantity of cast-iron. The Bessemer process is thus chiefly a refining process. It may be the combination of a refining process and a recarbonizing process, but it may also be a refining process in combination with a mixing, dilution or reaction pro-

cess, in so far as there may be, and, in fact, there usually is added to the bath of cast-iron a quantity of steel scrap. As I have already stated, in all processes in which refining is a feature the agent of refining is oxygen. The refining agent in the Bessemer operation is the oxygen of the atmospheric air.

The peculiarity of the open-hearth process which distinguishes it from the Bessemer and the crucible process is that the operation is carried on upon the bed of a reverberatory furnace, and the bath of metal is exposed to the action of the flame which traverses its surface, although this surface may be protected more or less by a layer of slag; as in the crucible process, so in the open-hearth, a great variety of mixtures may be made. The process may be either refining of pig-iron by oxygen derived from various sources; it may be a dilution of the carbon of the pig-iron by additions of wrought-iron or of steel. It may be a reduction and a carbonizing process, in which iron ore is the principal raw material, which is deoxidized by the addition of carbonaceous substances. It may be a carbonizing process, in which wrought-iron or low carbon steel is the principal component of the mixture—the carbonizing being effected by carbonaceous substances or by highly carbonized irons. Or it may be either one of these processes or a combination of two or more of them in combination with a process of recarbonization by the addition of a recarbonizer such as I have already mentioned in the crucible and Bessemer processes.

The mixture or bath of the open-hearth furnace may be formed in a variety of ways: an initial bath may be made of pig-iron, to which may be added successively and in small pieces the various additions for the purpose of diluting; or the additions may be made to the pig-iron all at one time, either before or after the latter is melted; or the initial bath may be of wrought-iron, or of steel, to which pig-iron or other substances may be afterwards added. Generally speaking, the open-hearth process is susceptible of a greater variety than either the crucible or the Bessemer process, inasmuch as all the possible mixtures of both the Bessemer and the crucible process may be used; they may be added to the bath either separately and in small pieces or all at one time, and either cold, or heated or melted. While the refining of the crucible process is generally accomplished by oxygen derived only from oxides of iron or other metals, and the refining in the Bessemer process by oxygen derived from atmospheric air alone, possibly supplemented by oxygen derived from steam introduced with the air, the refining in the open-hearth process is accomplished by oxygen derived both from the oxides of iron or other metals which are in the original mixture or which may be added to the bath, and from the excess of oxygen in the slag which lies upon the surface of the bath, as well as from the excess of atmospheric air or of carbonic-acid gas in the flame which traverses the bath.

The open-hearth process also gives greater facility for testing the quality of metal in the bath, both because the furnace is of a more convenient shape, and because the operation may be delayed for any length of time by the workmen in order to take out and test samples. The number of possible modifications of the open-hearth process is so great that they cannot all be specified; but I may briefly say that the open-hearth process includes every possible method of producing upon the bed of a reverberatory furnace a metallic bath, whose constitution is that desired in the finished product, namely, cast steel, and casting the same from the fluid state into ingots or other masses; and open-hearth steel includes all varieties of steel which are cast from a fluid mass contained upon the open-hearth of a reverberatory furnace, whatever may have been the method used to produce such fluid mass.

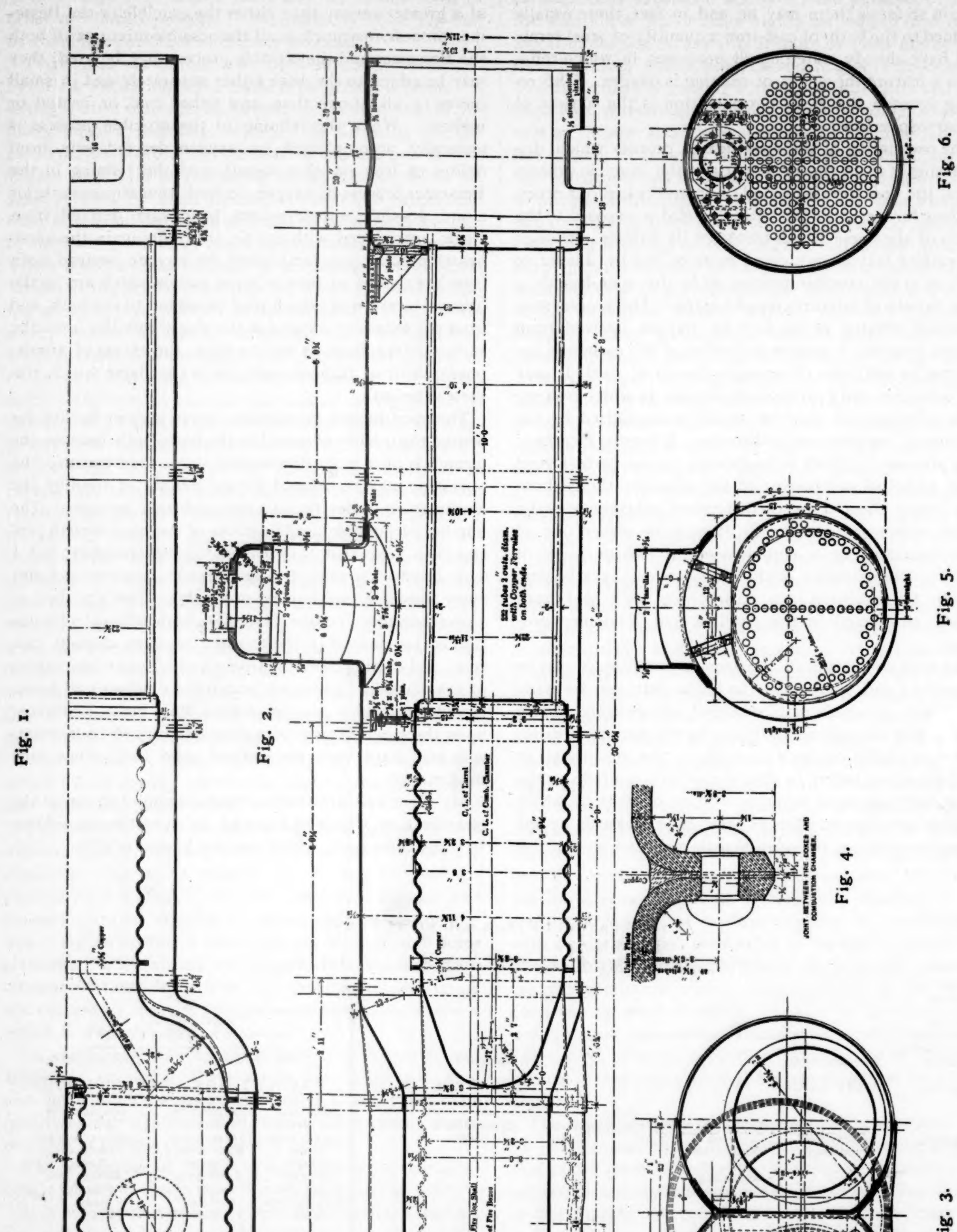
Mr. Kent has furnished us the following diagram of the classification which he adopted in his testimony, adding to it the term *mitis*, which was not known in 1883.

CLASSIFICATION OF IRON AND STEEL.--KENT.

Generic term	IRON.							
How Obtained	CAST, or obtained from a fluid mass.						WROUGHT, or welded from a pasty mass.	
Distinguishing quality	Non-malleable	Malleable					Will harden	Will not harden
Species	CAST IRON	CAST STEEL					WROUGHT IRON	WROUGHT STEEL †
Varieties	Ordinary Castings	Malleable Cast iron (Made from No. 1. by annealing in oxides.)	Crucible Steel	Bessemer Steel	Open-Hearth Steel	*Mit*	Obtained by direct Process from ores. Catalan Siemens Chenot and other process irons / Obtained by indirect Process from Cast Iron Finery Lancashire and puddled irons — Common wrought iron.	Obtained by direct or indirect process. German Shear Blister and Puddled Steels. †
No.	1	2	3	4	5	6*	7	8†

* No. 6., *Mitis* is the name given to a new product (having the same general qualities and produced by the same processes as soft cast steels, and therefore classified with them), distinguished by great fluidity in pouring and casting, which is secured by adding an alloy of aluminum to the metal before pouring.

† No. 8., Wrought Steel including German, puddled, blister and shear steel is nearly an obsolete product, having been replaced in commerce by those qualities of cast steel which will harden and temper.



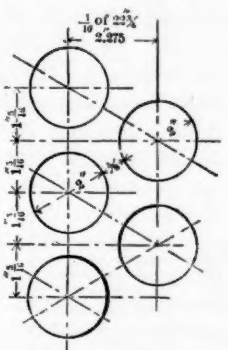
BOILER OF STRONG'S LOCOMOTIVE "DUPLEX."

STRONG'S LOCOMOTIVE "DUPLEX."

A DOUBLE-page engraving, from a photograph of this remarkable locomotive, was published in the last number of the JOURNAL.

This locomotive is, in many respects, a new departure from ordinary locomotive practice. It was built for heavy mountain passenger service on the Lehigh Valley Railroad, at the Wilkesbarre shops of that company, under the supervision of Mr. Alexander Mitchell, Division Superintendent of that line, from the design of Mr. George S. Strong. The engine, as will be seen from the engraving published last month, has six coupled driving-wheels, 62 in. diameter, a four-wheel leading truck and a single-axle or "pony" trailing truck under the fire-boxes. The cylinders are 20 × 24 in. The total weight of the locomotive is 137,000 lbs., of which 27,000 lbs. is on the leading truck, 90,000 lbs. on the driving-wheels and 20,000 lbs. on the trailing truck. This makes it probably the most powerful passenger engine ever built.

The most striking and most novel features of the engine



ARRANGEMENT OF TUBES

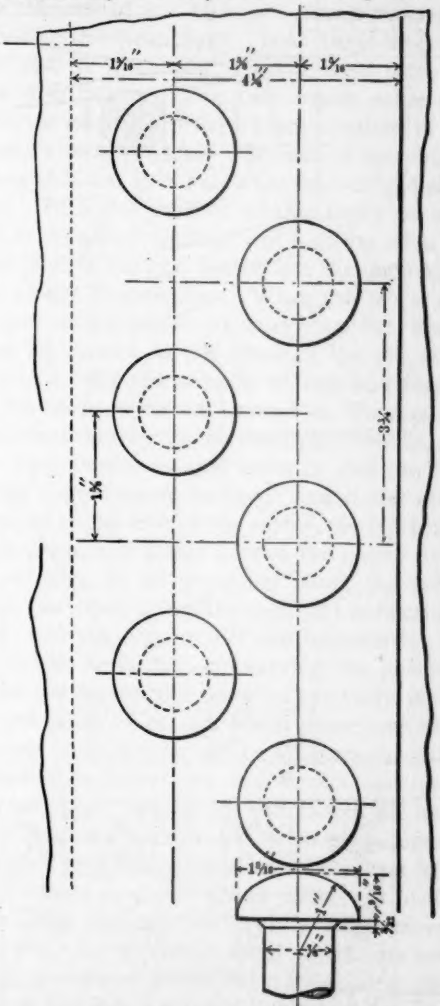
are the boiler and the valve-gear. Mr. Strong has assumed that for heavy and fast passenger service two things are required, first, a boiler that will supply an abundance of steam, and second, a valve-gear that will admit and exhaust the steam to and from the cylinders promptly. With a view to securing abundant steam-generating capacity he has designed the boiler represented by figs. 1 to 6. Fig. 2 shows a sectional view, on a vertical plane through the center of the boiler. Fig. 1 shows a half section on a horizontal plane through the center line. Figs. 3, 5, and 6 are transverse sections through the fire-boxes, combustion chamber and barrel of boiler, respectively. The engravings are from a standard four-coupled express-engine, similar to the *Duplex* in every respect except size.

As will be seen from the engravings, the boiler has a double fire-box, the fire-box casing being bifurcated, resembling somewhat the legs of a pair of trousers. Each of the separate fire-boxes consists of a steel cylinder which is corrugated circumferentially. The cylinders are united at their front ends to a single combustion chamber, also composed of a corrugated steel cylinder. The gases generated in the fire-boxes are discharged over a hollow bridge where they receive a supply of heated air to produce perfect combustion, and, by alternate firing, an incandescent fire, it is claimed, can always be maintained in one side to burn the gas produced in the opposite fire-chamber, which has been charged with coal last.

The steel junction piece, by which the fire-boxes are united to the combustion chamber, is made originally of three plates formed on dies in a hydraulic press and then welded up and flanged out to join the ends of the fire and combustion chambers, so as not to expose a single rivet to the direct action of the fire.

The combustion chamber is also a welded and corrugated steel cylinder, flanged out to receive a full-sized tube-sheet. These internal parts are capable of standing 1,100 pounds per square inch, external pressure. The longitudinal seams on the outer part of the boiler are all welded, and the circular seams, the only ones riveted, are united by a double row of rivets, placed as shown.

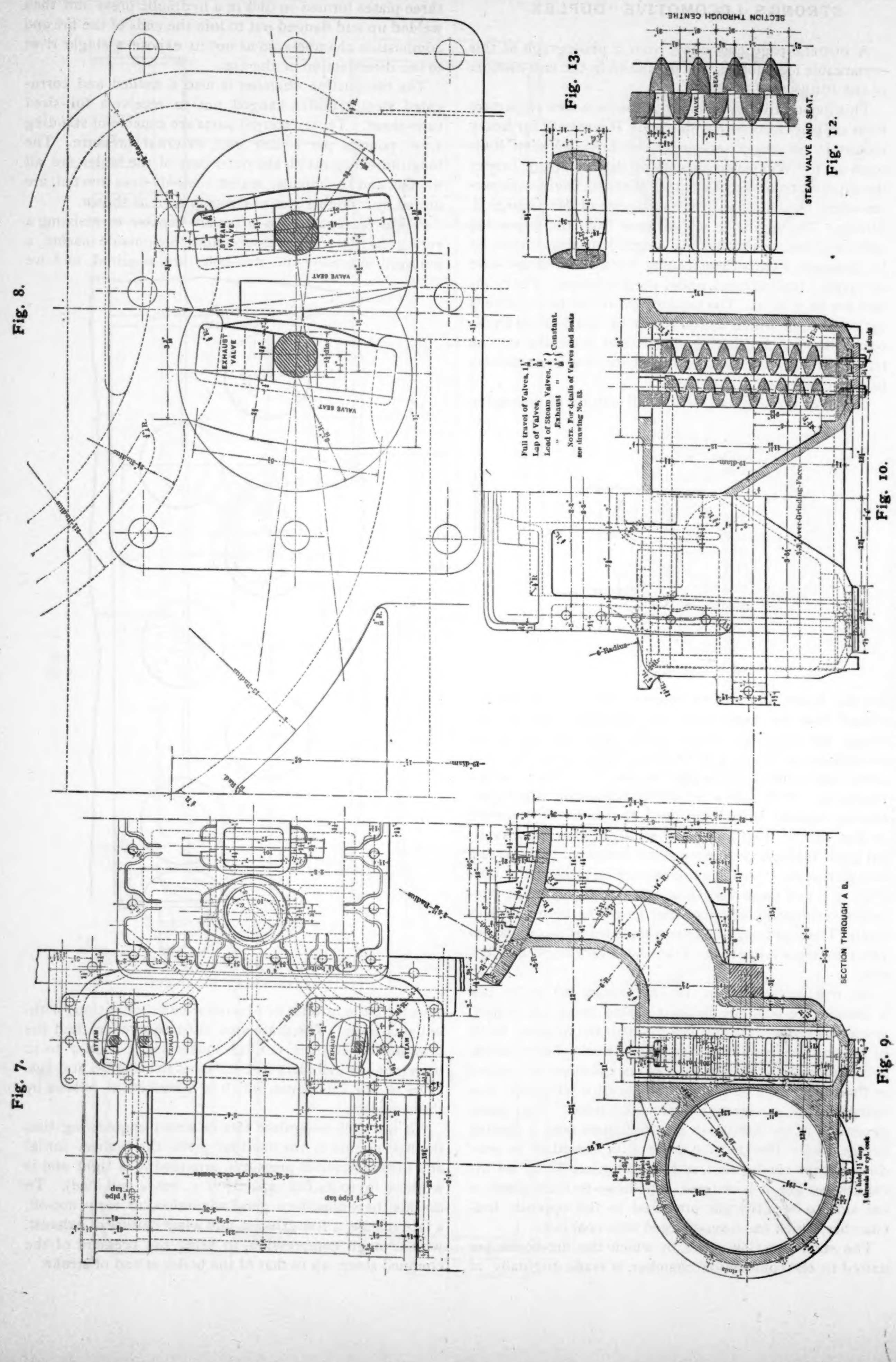
As the corrugated fire-boxes are capable of resisting a very great external pressure, and the outside casing a pressure internally, no stay-bolts are required, and we



ARRANGEMENT OF RIVETS.

thus have the novelty of a locomotive boiler entirely without stay-bolts. The grate area is 62 square feet, and the total heating surface is 1,848 square feet. Figs. 7 to 12 represent the cylinders and valves of this engine, and figs. 14 to 16 the valve-gear, which is described as follows by the inventor:

"It is a well-recognized fact in steam engineering that the best engine is the one that gives the highest initial and lowest terminal pressures, provided it is tight and is working up to its full capacity (*i. e.*, has a full load). To do this there must be a good admission, an early cut-off, a late release, a free exhaust and a late closure of exhaust, with enough compression to bring the pressure of the confined steam up to that of the boiler at end of stroke.



CYLINDERS OF STRONG'S LOCOMOTIVE, "DUPLEX."

"Much has been written on this question of compression, and some have asserted that it was impossible to run a locomotive at a high speed with any less compression than that given by the link motion, but they have not taken into account the question of clearances. We have found that when clearances are reduced compression must be reduced, and that with an engine having small clearances a very small amount of compression answers every purpose, and that more will deaden the engine.

"Here was a great problem to solve, and one that has taken years of careful experiment and investigation. We are required to produce an engine with independent steam and exhaust valves, which is at the same time simple, durable and practical.

"Many attempts have been made before, and many failures recorded. Careful investigation soon satisfied the writer that the flat slide or gridiron valve was the only one that would answer the purpose. Valves of this kind have stood the test for years with high pressure steam in both stationary and marine practice, but to be a success these valves must be allowed to come almost to rest while the load is upon them; wherever previously used some form of cam or tappet motion had been employed to actuate them. In our first experiment we tried a device of this kind, but soon found that with the rapid motion of a locomotive it would not do at all. We then devised the very simple arrangement of rocker shown, which is so adjusted that after a valve has traveled its lap it comes to nearly a full stop, while the corresponding valve at the other end of the cylinder is doing its work, and as the load comes upon the valve during this period of rest there is very little wear. As the steam of compression comes up under the valve at its period of opening there is a still further relief, while the exhaust valve does not move until it is relieved by expansion.

"The method of introducing the valves and seats is clearly shown by the drawings. The valve-seats are plugs, fitting in holes bored in the passages from the saddle to the cylinder, the ordinary steam-chest being dispensed with. The valves are let into grooves milled or planed in the seats, so arranged that the valves are free to move up and down in the seats.

"There are ten ports in each seat on a 19 × 24 in., or a 20 × 24 in. cylinder, each port being 4⅝ in. long and ¾ in. wide, giving a total port length of 46¼ in., in each valve. This length is also, of course, that of the lead line, as against the 16 in. of an ordinary locomotive. This arrangement, even when the engine is making 250 revolutions per minute, gives an initial pressure within 2 pounds of boiler pressure, and does not allow more than 5 pounds drop to the point of cut-off; while the ordinary form of valve will entail a loss of 15 pounds between boiler and initial pressures, and another 15 during the period of admission, making a loss of 30 pounds between boiler pressure and that at the point of cut-off; while under similar circumstances we do not by any chance lose 10 pounds. We cut off at 4 in., and hold on to the steam until the last inch of piston travel, thus getting 6 expansions. The exhaust does not close until 3½ in. from the end of the return-stroke, avoiding excessive compression. An ordinary locomotive loses 33 per cent. of the mean effective pressure from compression, which necessitates a late cut-off and not more than 3 expansions, in order to maintain the same mean effective pressure that we get with 6 expansions. Now, it will be readily seen why the link-motion is not good for very fast and heavy work. It can neither get the steam in nor out properly. In losing at both ends, it exhausts at too high a pressure and does not allow an initial pressure at all near that of the boiler. All these objections are entirely overcome by the valve-gear shown, which is of the radial type.

"The motion for all the valves on one side of the engine is obtained from a single eccentric, one motion of the lever attached to the eccentric moving the valves the amount of their lap and lead, and another motion produces the opening in addition to the lead. There are two levers worked from the same eccentric strap; one being bolted rigidly to it, while the other has a pin forged on the end of it. This pin has a bearing in a bushed hole in the strap itself. Both these levers have a fulcrum pin, at a certain distance from their ends, connected with one end of a link whose other end is hung by means of a pin from a block, capable of being moved along a sector or arc. The path of the pin, when moved along this arc, is radial to the fulcrum pin already mentioned. Thus the position of this block on its sector, which is regulated through the medium of a reach rod by the lever in the cab, determines the inclination of the travel of the fulcrum pin. When the block stands in the center of the sector, as shown on the drawing, there is no inclination to the travel of the pin, and the valve is moved only the amount of lap and lead. If, however, the block is moved forward on the sector, the fulcrum pin travels over an inclined path, which incline represents the opening of the valve in addition to the lead, and the engine moves forward; and if the block is moved forward to the end of the sector, the full travel of the valve is given, and steam follows the piston 20 in. of its 24-in. stroke; if, on the other hand, the block is moved back past the center, the path of the fulcrum pin is reversed, and the engine will run backwards. Thus it will be clearly seen that, by varying the position of the block on the sector, the travel of the valve is varied as well as the point of cut-off, which latter may be anywhere between 4 in. and 20 in. In all cases the exhaust valve is allowed to travel its full stroke, and as it is worked by the lever having the pin forged on its end, and from a separate fulcrum pin, with an independent link, block and sector, its travel may be varied at will, and so, of course, may the steam valve. In ordinary working, however, the exhaust block is never moved on its sector, except for reversing, when both steam and exhaust blocks are moved at the same time; after the engine is started the steam valves are hooked up, but the exhaust is not disturbed. The steam valves are given ⅛-in. lead and the exhaust $\frac{1}{16}$ in."

The performance of this engine will be watched with a great deal of interest. It is now in service on the Lehigh Valley Railroad, and it is reported that it makes an abundance of steam with the fastest and heaviest trains up the mountain grades of 96 ft. per mile, doing the work of two ordinary locomotives with the finest buckwheat or pea coal (anthracite), or with screenings with all the culm in it.

This locomotive is controlled by the Strong Locomotive Company, of 239 Broadway, New York, of which company Mr. A. G. Darwin is President; George S. Strong, Chief Engineer. The directors of the company are: A. G. Darwin, C. C. Worthington, Thomas F. Rowland, H. G. Morris, Geo. D. McCreery, Geo. H. Meyers, and Geo. S.

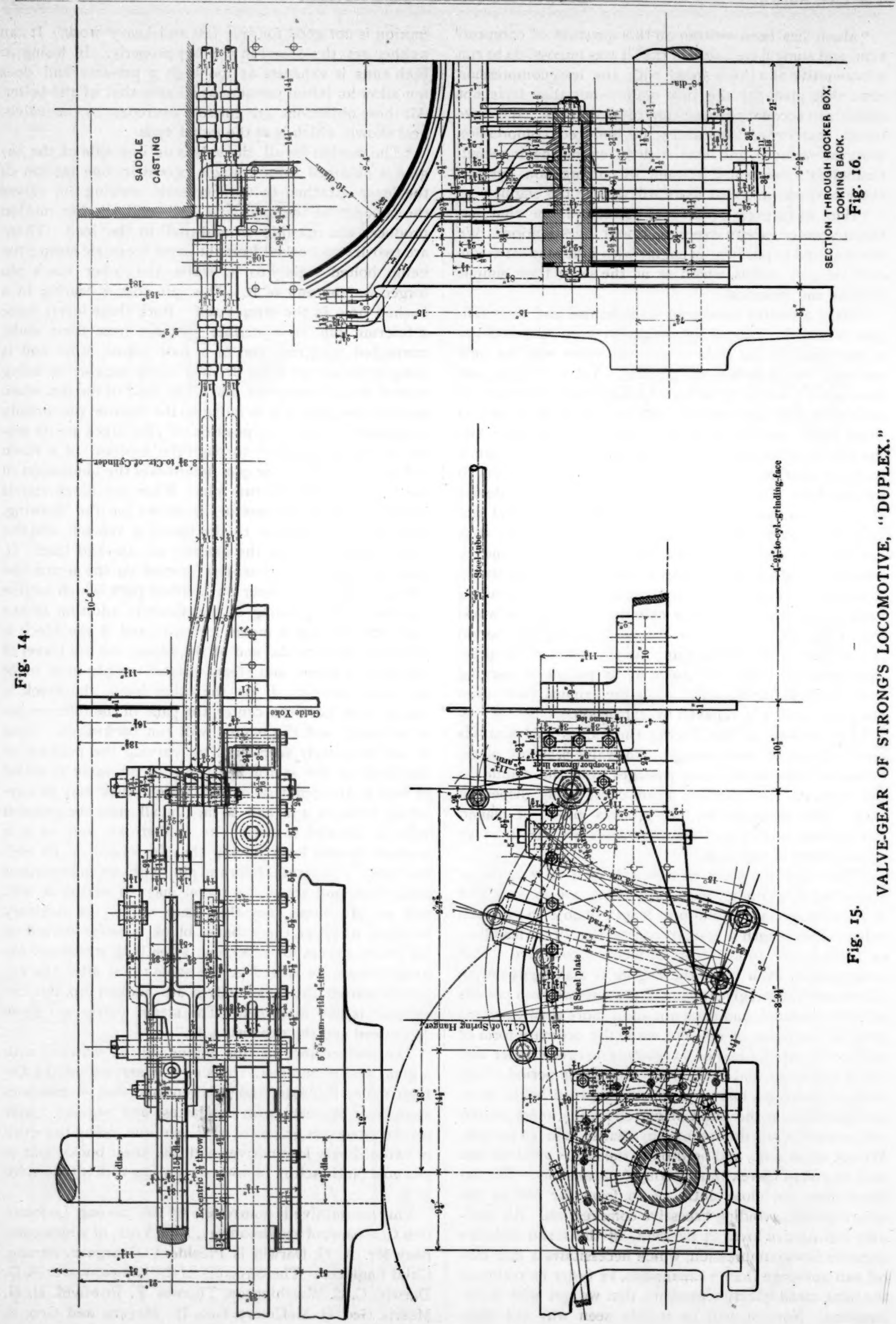


Fig. 14. Fig. 15. Fig. 16.

VALVE-GEAR OF STRONG'S LOCOMOTIVE, "DUPLEX."

Strong. It is the intention of this company to have the locomotives built by regular builders except the boiler, which requires special machinery for welding, flanging and corrugating. This machinery the Continental Iron Works, of Greenpoint, Brooklyn, have constructed and have in operation, and they will make the boilers, or supply the welded, flanged and corrugated parts for their construction elsewhere. The other parts of the locomotive do not, of course, require any special plant or other tools than those found in any shop well equipped for locomotive building.

Latowski's Bell-Ringer.

The accompanying engraving represents a bell-ringer invented and patented by Mr. Robert Latowski, of Munich, Germany, which has already come into extensive use (over 1,500 having been made) on German railroads, and also for steamboats, factories, etc.

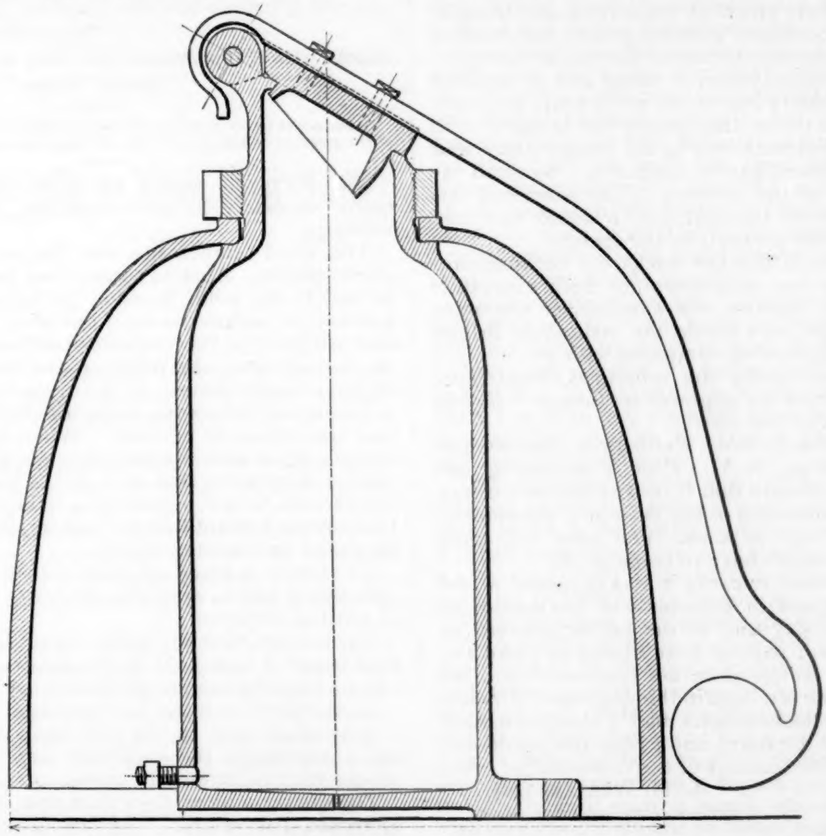
As will be seen from the engraving—a cross-section through the center—the bell-ringer is a box or chamber, to which the bell is secured at the top by a nut or collar.

Steam is admitted into the chamber by a small opening at the bottom. At the top is a much larger opening, which is closed by a safety-valve; to this safety-valve is attached the hammer, which strikes on the outside of the bell. Owing to the size of the safety-valve opening, a larger amount of steam will escape than that entering the chamber in a given time, and the sudden decrease of pressure thus produced will cause the valve to shut quickly. The admission of steam being continuous, the opening and closing of the safety-valve will produce a continuous oscillation of the hammer attached to it, and a consequent ringing of the bell.

For the purpose of increasing the lift or stroke of the valve and hammer, the valve is provided with an interior ring or boss, which, acting as a loose piston, does not close the opening tightly, but requires a certain lift to give free egress to the steam.

When at rest (as shown in the cut) the hammer does not touch the bell, but when the valve closes the weight of the hammer and the spring of the handle cause it to strike; the rebound from the bell also assists in the opening of the valve. The spring or handle carrying the hammer is prolonged over the hinge of the valve, serving both as a check to prevent it from opening too widely and as a spring to assist its rapid closing.

A small hole is bored at the bottom of the chamber to discharge any water which may form inside it by condensation.



LATOWSKI'S BELL-RINGER.

In practice it is found that a steam pressure of about two atmospheres is quite sufficient for the working of this apparatus, and that the bell will be struck at regular intervals, while the operator or engineer will readily learn to give such signals as may be desired.

The size which the makers recommend as suited to large locomotives has a bell (of cast steel) about 19¾ in. diameter, the weight being about 170 lbs. The apparatus can, of course, be made of any size required.

Enterprising Journalism.

The following correspondence has been made public;

"*Judge Thomas Russell, Chairman Massachusetts Board of Railroad Commissioners, Boston, Mass.—Dear Sir:* We beg to inform you that we now have in our possession, subject to your order for production at the investigation of the late disaster, the two broken hangers which, in our judgment, were undoubtedly the immediate cause of

the disaster, since nothing worse can have existed in a bridge which stood up 11 years, and they came from just the point where the facts seem to require the break to have been—at the first panel of the north truss from the farther abutment.

"They are the two floor-beam hangers. One of them was cut completely off at two points by old and deeply rusted breaks, leaving about one-twentieth inch effective section. It would not hold up 100 pounds safely. The other is cut, likewise, by two old rusted cracks at two different points, for about one-fourth its periphery and one-eighth its section. It would safely carry about a ton, perhaps.

"We sent Mr. Henry S. Pritchard, civil engineer, a practical bridge man, to get the bottom facts for us, if he could, and he did so. He arrived on the ground 27 hours after the accident, spotted the probable cause of the difficulty, noted that the broken parts were being hauled off, to be scraped, apparently; asked one of the laborers employed in the work to knock out the pin for him, and set these broken parts free, which he did at once, and brought them on to us in accordance with his general instructions to pick up any specimens of technical interest he could get. We had no idea nor expectation of being able to pick the key to the whole mystery out of the scrap heap, but, having done so, propose to see that proper use is made of it, by delivering the specimens only to the proper party, and we hope only for investigation purposes, We shall exhibit the specimens at the meeting of the American Society of Civil Engineers to-night, and I would like that they should remain the property of the society,

"I should add that, beside the cracks, the workmanship and material of the two specimens are both execrable. Taking into account, likewise, the nondescript character of the bridge 'design' as a whole, the Ashtabula Bridge was a triumph of engineering compared with it.

"We have received to-day the subjoined dispatch (or Mr. Pritchard did) from an engineer in Boston who has likewise acted for us in this matter.

"'Henry S. Pritchard, care Wellington, *Engineering News*, Tribune Building, N. Y.: Prof. Vose, *having authority* (all italics ours) says that if broken pieces are sent at once to the Superintendent of the Boston & Providence Railroad, *no remarks will be made.* You need not come now. Probably you won't have to come at all.'

"We don't know what remarks it was supposed would be made, but as we came in possession of the specimens in a perfectly proper way and in the public interest, as did also Mr. Pritchard, anyone is at liberty to make any remarks they please, so far as we are concerned, and we shall exercise the same privilege in the *Engineering News*. As an engineer and Massachusetts man I blush that such things are possible in the State, and I hope our spade will be called a spade in the findings of the commission. Respectfully,

"A. M. WELLINGTON,
"Editor *Engineering News*.

"March 15, 1887."

"*A. M. Wellington, Esq., Editor Engineering News.—Dear Sir:* In your favor of 15th inst. you notify us that you have portions of two broken floor-beam hangers taken from the wreck at the South Street crossing on the Boston & Providence Railroad, and that they exhibit old and deeply rusted breaks, which, in your judgment, were the immediate cause of the disaster.

"The other portions of these same two hangers, showing the other sides of the breaks, are now in the office of the Commissioners, having been preserved by the company and sent to us, in accordance with an agreement entered into the day before your reporter made his discovery. Both portions of the two broken hangers were examined by several experts and by myself three or four hours after the accident, and it was at that time that the company, in accordance with my request, agreed to preserve them. Furthermore, an expert was employed by the Commissioners, and another by the railroad company, to make a critical examination of the whole wreck, and to see that any other important portions were also preserved. The portions of the hangers in your possession belong to the railroad company and not to us, and we have no doubt that the company, as soon as they are restored to it, will at once, in accordance with its agreement, place them before us for further examination. Upon this point you need have no anxiety.

"It is not for us to characterize the action of a reporter who, taking advantage of the privileges accorded him, carries off important portions of a wreck without the consent of the owner, but you can readily see that it would be necessary to exclude all reporters from access to wrecks if the course adopted by Mr. Pritchard, in accordance with your instructions, was considered justifiable and should be adopted by other journalists.

"We appreciate the evident desire to be helpful which prompted your action, and thank you for the expert opinion contained in your letter.

"Hon. Thomas Russell, the late Chairman of the Board, to whom your letter was addressed, died about a month ago. Yours,

"GEORGE G. CROCKER, Chairman.
"For the Board of Railroad Commissioners."

Steel: Its Properties; Its Use in Structures and in Heavy Guns.

[Abstract of paper read before the American Society of Civil Engineers, at the meeting of March 2, by Mr. William Metcalf.]

MR. METCALF begins his paper by a few definitions, made necessary by some apparent confusion in recent writings.

The word temper has two distinct meanings among steel-makers. Applied to steel not hardened, the temper is said to be mild, medium or high, according to the amount of carbon the steel contains; thus we recognize and use daily in the crucible-steel business tempers, each so distinct from the other in the fractured ingots, that there is no uncertainty in their selection and separation.

The mean difference in carbon between any two adjacent tempers is .07 per cent. When speaking of the temper of a piece of tempered steel, the final condition of the steel is referred to, that is to say, it is straw-color, orange, light brown, brown, pigeon-wing or blue, as the case may be. If the piece has not had the temper drawn, it is said to be hardened and not tempered.

To temper a piece of steel is to heat it, harden it by quenching, and to draw the temper to the color or degree of softness required.

The recent United States Navy specifications would read better if they said to be annealed, hardened in oil, and to have the temper all drawn out.

Steel-makers call the last operation drawing black.

Annealing steel is the operation of heating it slowly and uniformly to the necessary degree to soften it, or to relieve internal strains, or to secure uniformity of texture.

The question of what is steel was left in a mixed state by recent discussions. The law says that "steel is iron which has been produced by fusion by any process, and is malleable."

Mr. Metcalf offers a new definition: "Iron is a liquid." This was suggested independently by two persons, U. S. Senator John T. Morgan and Prof. John W. Langley, of the University of Michigan. Professor Langley was the first to observe the varying rate of expansion due to increase of temperature between high steel and low steel. He was also the first to note the presence of free oxygen dissolved in iron, a discovery confirmed by late researches of European chemists.

This liquid, which we will consider now in the form known as steel, congeals at a high temperature; as it congeals it crystallizes in as many forms almost as are to be found in snow-flakes. The sizes and forms of the crystals are affected, *first*, largely by the rate of cooling; slow cooling favors the formation of large crystals and quick cooling produces small crystals. Chernoff observed farther that agitation produced fine crystals, and gave this as the reason why a heavy hammer, thoroughly and quickly applied at the right time, produced fine grain, increased density and greater strength.

Second.—The size and form of the crystals is affected by the foreign substances present.

The effects of carbon are so even in well-melted ingots that 15 tempers can be selected with certainty, and skilled operators can even make this into 30 tempers.

Third.—The crystals are affected by the walls of the mould in which the liquid is cooled.

This is very marked in chilled iron, and in what the melters call scalded ingots. The effect of the wall can be noticed also in any casting.

When steel congeals, the foreign substances are driven out to some extent by sudden cooling, just as cold ice is clearer and sounder and stronger than slowly-formed ice.

In chilled iron the graphitic particles are found just at the edge of the chill; a scalded ingot looks like chilled iron, but the crystals are not hard like the crystals of a true chill, and polarized ingot would be a better name. Such ingots are weak and brittle.

There is much evidence to show the tendency to the extrusion of foreign elements as molten steel cools, of which the two cases following are given.

An ingot weighing several tons was drilled at the top and bottom, and analyses gave

	For the top.	For the bottom.
Silicon	.023	.078
Phosphorus	.014	.032
Sulphur	.023	.027
Manganese	.306	.425
Carbon	.725	.775

A large bar of steel made for rolls by Krupp, of Essen, was turned and bored, and the turnings were analysed, with the following result:

	Outer.	Inner.
Silicon	.130	.195
Phosphorus	.044	.050
Sulphur	.000	.005
Manganese	.448	.425
Copper	.234	.224
Carbon	.852	1.020

The latter case is not so marked, except in the carbon, as in the case of the ingot, yet these two cases indicate that the elements sink by gravity, and leave the surface as it cools.

In the light of the liquid theory, the above cases illustrate a reason for the well-known unequal distribution of the elements in steel.

They also point to the idea that the elements in steel are there as alloys or in solution, and not in chemical combination. It may be true that there is a definite carbide of iron in steel, yet, if there is, it is evidently there in solution.

Mr. Metcalf's experience leads him to believe that there is no property of steel which is not common to cast-iron; for instance, the hardening of steel and chilling of cast-iron, and the softening of either by heat. He believes that from the mildest steel, containing only traces of carbon, to the highest cast-iron, we have simply one substance, iron, containing various quantities of alloys or substances in solution, and that the properties which we observe vary only in degree, due to the quantity of alloy that is present.

In considering the effect of temperature on steel, Mr. Metcalf says that it is well known to all workers in steel and cast-iron, that the whole structure of the ingot or casting varies very decidedly with the temperature at which the metal is poured, and this fact is constantly made use of to produce desired results. But outside of those who have a large and varied experience with steel, it is not so generally known what a mercurial substance it is, both in volume and structure; and that in every piece of steel that is in existence to-day, there is a sure record of the last temperature to which it was subjected, as well as of the manner in which the steel was worked.

For every variation of heat which is visible to the naked eye there is a corresponding variation in structure, which is equally visible to the naked eye if the record be opened by fracturing the piece.

Professor Langley's research on the specific gravity of differently heated pieces of steel, shows that there is also a different specific gravity for each difference of structure.

This being the case, there is of necessity a permanent internal strain for every variation in specific gravity, because each change in specific gravity means, of course, a corresponding change in volume. These strains vary from the slightest up to those that produce rupture; the piece cracks.

A piece of 0.53 carbon steel will vary in specific gravity from 7.844 to 7.818, from the bar finished at ordinary red heat to the bar cooled from a scintillating heat respectively, a difference of 0.026. A bar of 1.079 carbon, under the same conditions, will vary in specific gravity from 7.825 to 7.690, a difference of 0.135.

This shows that for a double quantity of carbon we have five times the difference in specific gravity, due to an equal difference in temperature. This, the writer believes, is the "mystery" of the brittleness and the tendency to crack in high steel. If engineers who are in the habit of dealing with structural steels are disposed to think that these are both cases of high steel, he explains that these particular experiments were made on a fine grade of tool steel, and that, compared to the ordinary Bessemer and open-hearth steels, the 0.53 carbon tool steel would grade, in softness and ductility, about the same as 0.25 carbon Bessemer steel.

Experience teaches that this rule of change in volume holds good all the way through the carbon series. A piece of 0.10 carbon steel may be heated white hot and plunged into water without breaking it; but if the same piece be quenched at a red heat, and also at a white heat, in different parts, and the parts are then broken, the different grains of the pieces will present a record of temperatures which, once seen, will never be forgotten. On the other hand, if a piece of steel of 1.079 carbon be quenched at a bright orange color, it will be a very remarkable piece of steel if it does not fly to pieces.

This question brings us to the subject of annealing, a consideration of which will bring out some of the most useful and important properties of steel. Every piece of steel is at its best in all physical properties when it has been annealed, so that it is in the condition which steel-makers call refined, that is to say, when the grain is in the finest condition possible, or when its crystals are the most minute and most uniform in size.

This statement is subject to a slight modification in considering a piece of hardened steel; when steel is hardened properly the grain is slightly finer than it would have been if it had been allowed to cool slowly; but the difference is very slight, and if the hardened piece be subsequently annealed this difference disappears.

Each temper of steel refines at a different temperature.

A piece of 0.10 carbon steel will refine probably at a lemon color. A piece of 0.30 carbon steel will refine at a dark lemon or bright orange color. A piece of 1.00 carbon steel will refine at a dark orange color, or the color that is reached just as the last shades of black disappear.

As a rule, the best heat to harden at is the refining heat, and the same heat is a good guide for annealing, although the heat may be raised very slightly in annealing high steel, but it should be done with great care, and it should be lowered considerably in annealing mild steel to avoid over-annealing. It is remarkable, and probably the most important property of steel, that, no matter what the grain may be, no matter how coarse from over-heating, or how irregular from uneven heating, if it be heated uniformly to the refining heat and kept at that heat long enough, the crystals will change in size and will all become small and uniform, so that the fracture will be so even that it will be called fine-grained and amorphous. The magnifying glass will, however, reveal a crystalline structure in the most beautifully refined steel. If a piece of chilled cast-iron be kept at a bright red heat for an hour or two, the chill will not only become soft, but the long crystals will disappear altogether, and the whole piece will be ordinary-looking gray cast-iron.

If a scalded or polarized ingot be kept at a bright red heat for an hour or two, it also will lose every trace of its needle-like polarized crystals, and will become a uniform fine-grained piece of steel, and it will be as tough as if it had never been scalded and brittle.

If any ingot be annealed properly it will lose every vestige of its distinctive carbon crystallization; it will become refined and tough.

Unannealed ingots are brittle, easily broken with a

sledge, and are distinctively marked; annealed ingots are fine-grained and tough, and must be cut with a set to be broken; and when broken an effort to grade them by the fractures is the wildest guess-work, in which none but a great expert should indulge. If a well-annealed piece of steel is the best piece of steel in every respect, an over-annealed piece of steel is the very worst piece, and should always go right back into the melting furnace. Over-annealed steel is brittle, harsh, not ductile, will not harden, and will not temper, and there is no way but melting to make it good.

The time required for annealing is longer for a large than a small piece; the correct time must be arrived at by experience.

The writer then considers the question whether steel and iron crystallize in service after a long duty, and having been subjected to many repetitions of strains, vibrations and shocks. If it be true that the largest crystals and the coarsest and weakest structure are formed when iron and steel are allowed to cool slowly and in a state of rest; and if the finest crystals and the best structure can only be formed by quick cooling and the violent agitation of the hammer or of the rolls; or by careful heating to just the right temperature to cause the formation of fine crystals, it would seem somewhat anomalous to assume that this is all reversed in the cold state, and that cold iron and steel can be shaken up into coarse crystals and a weak condition.

It may be possible that such an anomaly could exist, but it seems more reasonable to suppose that when an axle or a crank-pin breaks and develops in the interior large, fiery and weak crystals, that those crystals were formed there by too much heat, too slow cooling, and too little work when the piece was formed.

It is proper to remark here that the hammering of a round piece between flat dies is a dangerous operation; it is a common thing to find round-hammered bars of steel burst in the middle for long distances, of which there is no evidence at the ends or on the surface; therefore, round pieces for structural purposes would be safer if they were hammered in swedges or rolled in grooves.

Piped ingots should be looked after too; it is quite likely that the hollow rail that broke with such disastrous results in New England lately was rolled from a piped billet.

As to the physical properties of steel, mild steel, such as is used commonly for structural purposes, is more ductile, stronger and tougher than iron; it is more easily and safely produced in large masses than iron, and when worked properly it can be put into the most difficult shapes, and be made to do good duty.

High steel is hard and brittle, and generally of great tensile strength; its use is hazardous, because of its great change of volume for a slight change of temperature; yet it can be made very ductile by careful annealing.

When steel is to be subjected to repeated deflections or alternations of strain, the mild steel is the more enduring; but when steel is to be subjected to rapid vibrations, as in a pitman or a hammer rod, a higher steel is much better than dead soft steel. In using higher steel, however, it is important to have it well annealed and perfectly smooth. Instances have been known where a break in a hammer-rod could be traced to a slight tool-mark. No sharp angles or corners should be allowed in structural steel.

A great railroad company discovered not long ago that the moduli of elasticity of mild, medium and hard steels, tempered and untempered, were practically the same. Next, it was decided that the strains in coiled springs were torsional; then the moduli of elasticity were applied to the formula for torsion, and it was discovered that if the bars were of the proper size it would make no difference how much or how little carbon they contained, nor whether they were tempered or untempered, the springs would be all right. Finally, it was specified that no spring should contain less than 0.90 carbon, and, of course, they were to be tempered. This may sound absurd, but it only proved the wisdom of the engineers; they were smart enough to test their own formula, and the result was a well-designed set of springs and an admirable specification.

Mild steel does not afford good resistance to abrasion, it is too ductile and flows too readily; the flow causes heating and increased friction, and the low tensile strength yields to the friction.

The effect of the chemical constitution of steel is very marked, and is well defined in high tool steel, but it is not so well defined in mild steel, nor in Bessemer and open-hearth steel; therefore engineers do well not to meddle with chemistry at present; but it is safe to assume, in all cases, that the nearer the steel comes to being pure iron and carbon the better it is.

It may be gathered, from what has been said that in general it is better and wiser for engineers to adhere as closely as possible to mild steel for large structures, where the material is used in comparatively large masses.

First, because it is more ductile than high steel, and therefore not so liable to break under sudden stress; and second, because it can be safely worked into shape by less skilled hands than are required in the manipulation of high steel; yet there are cases where it is wise to take advantage of the superior strength of high steel in the largest structures, of which we have notable examples in the staves of the arches of the St. Louis Bridge, and in the wire of the cables of the East River Bridge.

On the other hand, there seems to be danger in the enthusiasm of some of the admirers of mild steel, whose statements that it will stand any amount of "abuse and punishment," etc., may mislead them and others into the idea that it can be handled without even as much care as is ordinarily bestowed upon wrought-iron.

If the statements made in this paper are accepted as facts, it must be obvious that care is always necessary, especially as regards heat, and particularly uneven heating. Some instances are given to illustrate this point.

In reference to steam boilers, so far as strains are concerned, it would seem that high steel would be the best; but when we consider the daily alternations of heat and cold to which boilers are exposed, fire on one side, water on the other, and the general ignorance of physics of the men who handle them, it is obvious that mild, tough steel is the only kind that is safe, and the milder and tougher the better.

STEEL FOR GUNS.

Mr. Metcalf refers at some length to the arguments brought forward by the advocates of built-up guns, Mr. Edward Bates Dorsey and others, and says that his preceptors. Wade and Rodman, held that the qualities required in a gun were elasticity, springiness and power to resist abrasion, combined with high strength and the power to offer a uniform resistance in every direction to all of the strains to which it might be subjected.

All of these properties were reached in the highest degree possible in the material with which they had to work, and none of their guns ever failed.

If Rodman had lived, the advent of good steel in great masses would at once have been seized upon by him, and before now he would undoubtedly have cast the best and biggest, the safest and the cheapest, guns that were ever made.

Rodman was a true engineer, and it was a cardinal principle with him, that any gun had a certain number of foot-tons of work to do, whether it were to batter down an earthwork or to sink a ship; and he always claimed that the best gun was the gun that would do this work for the fewest cents per foot-ton, including in the cost the making of the gun.

The writer does not believe that a good gun could be made of dead soft steel. The bore of such a gun would enlarge from the first round; the lands of the rifling would give way under the pressure of the projectile; the vent would wear out rapidly; and altogether he would expect that after a hundred rounds such a gun would be about as symmetrical as an old battered hat.

The objection to proposed methods is: To the building-up system; to the notion that "definite shrinkage" is a practical possibility; to the idea that rings can be so shrunk together that each shall be strained to exactly its elastic limit, when, in fact, that elastic limit cannot be known; to the enormous cost of unnecessary operations,

and to the doubtful utility of the operations after they are performed.

Lieutenant Ingersoll says: "What we want with gun-steel is uniformity; but this should be a development with high rather than with low qualities, and the tendency and march of events indicate that this will be attained by: First, a more intimate chemical knowledge of steel; second, a less barbarous forging-machine than the hammer; third, annealing; fourth, oil-tempering."

As to the "first," when the departments begin to dabble in the chemistry of steel there will be no more guns made; what is needed instead is an intimate knowledge of the physics of steel.

To the "second" all will agree who know anything of the subject, and, the writer adds, we want a less barbarous forging-machine than the hydraulic press. We want no forging-machine at all; the steel can be made to forge itself by static pressure and by heat.

To the "third" there can be no objection, as there is no known way of getting improper strains out of high steel except by annealing.

The "fourth" is of doubtful utility. It is not probable that the benefit derived, if there be any, can compensate for the cost, especially when we reflect that the parts are annealed subsequently. What is the object of the annealing? Mr. Davenport answers that as follows:

"It is generally admitted that the effect of tempering in oil or any other liquid is to *fix*, by rapid cooling, the amorphous conditions existing in the heated mass, thus preventing the formation of a coarsely crystalline structure, and destroying the irregular and more or less crystalline condition existing in every forging of considerable size when it leaves the hammer.

"Besides this, the molecular condition of the mass is far more uniform after treatment than before."

Thus, the writer believes, is the whole forging business effectually damned by the trusted defender of the system, whose unquestioned skill and success in this hazardous business entitle his statements to the fullest credence.

The writer then quotes at some length the experiments made by the late A. L. Holley, and his statements as to the cost of steel and iron guns in 1865, and gives the arguments for the Rodman gun as follows:

"For the information of any who may not know, I will say that the Rodman plan consists in casting a gun on end, breech down, with a hollow core. Water is circulated through the core to cool the interior rapidly, and a strong fire is kept in the pit to keep the exterior of the gun warm, thus forcing the metal to contract all in one direction and on the interior. The operation is so simple, so easy, so sure, and so scientific, that it is beyond criticism, and it would seem superfluous to add any further arguments than those given in the early pages of this paper, to make clear the possibilities of this process, properly applied, to steel. There are plants in the country now which only require the addition of some pits and molds to prepare for the casting of 40-ton guns for trial; and the extension of these plants to the casting of 100-ton or 150-ton guns would cost but a comparative trifle.

"The cost of one huge hammer, or one hydraulic plant, would build a half-dozen casting plants.

"Splendid steel castings up to 30 and 40 tons weight can be bought now for less than 6 cents a pound, while we are told to think of 40 cents a pound as the price of rough-bored, rough-turned, annealed, oil-tempered and annealed gun parts. My own opinion is that 40 cents a pound is not a high price for such work.

"To this price must be added probably 40 cents a pound more for the cost of finishing these much treated parts; this brings us very close to the figure given for the Krupp gun."

Steel-makers are invited to put up large plants for making gun parts; but such plants would have no commercial value, and would be useless when the appropriations for heavy guns of this class ceased.

Mr. Metcalf believes the built-up gun to be unscientific and unmechanical, and suggests that before going to enormous expense to provide plants and to build such guns, it would be wise to spend $200,000 or $300,000 to test the Rodman plan applied to steel.

The paper concludes as follows:

"For ready reference for the use of engineers, the statements made may be summarized as follows:

"Iron and all metals are liquids.

"Cold steel is congealed iron, containing in solution various ingredients, which give to it certain marked properties.

"Heat is the power which gives to steel all of its good and all of its bad conditions.

"Steel is as mercurial in structure and volume as mercury is in volume.

"Slow, quiet cooling from a high temperature causes the formation of large, irregular crystals, and renders the steel weak.

"Quick cooling and agitation form small, uniform crystals and a strong condition.

"The application of heat alone will change the form and the size of the crystals.

"The change of volume due to a unit of heat increases as the content of carbon increases; therefore high carbon steel must be handled with exceeding care.

"The temperature to which it was last subjected, moderated by its subsequent treatment, is always recorded in the structure of steel, and may be read there if the piece be fractured.

"Annealing, making soft, ductile and uniform in texture, is the most important of all operations from an engineer's point of view.

"Steel being crystalline, has no fiber; therefore there should be no sharp angles, no sharp edges, and no unfilleted corners; the surfaces should be smooth and free from tool marks or indentations caused by sledge blows and the like.

"With our present knowledge, the *best steel* for structural purposes is that which is most nearly composed of iron and carbon.

"Finally, good steel, properly worked, is the most useful of all of man's productions, and it may always be relied upon to do its full work to its utmost limit; but if the laws of its being be violated, it will as certainly respond, causing disappointment and disaster."

The New Naval Vessels Authorized.

(From the *Army and Navy Journal.*)

We find that there is a great lack of exact information as to what has been done by Congress for the increase of the navy. To make this clear we give here a table showing what vessels have been authorized, their size, proposed armament, cost, speed and present status. This will give a clear idea of the number and character of the vessels constituting our new navy, the last of which should be in commission by 1890.

The total sum thus far allowed by Congress for the new navy is, it will be observed, nearly $31,000,000. Of this a little over $3,000,000 is provided for guns, and a little over $4,000,000 for armor. This is over $7,000,000 in all; a sum quite sufficient to make a beginning, and to stimulate our manufacturers to exert themselves to meet the requirements of modern warfare. It should be remembered that this is but a beginning, and that no provision has thus far been made to meet the demands of the army for heavy ordnance or coast defenses. The new navy thus far authorized includes 22 vessels, of different sorts, having a total tonnage of 65,609, and armed with two 12-in. guns, twenty-six 10-in., twelve 8-in., eighty-one 6-in., the armament of two large cruisers not yet being determined. Besides this we shall have the dynamite vessel, torpedoes and Hotchkiss and Gatling guns. The appropriations for armament of the new naval vessels amount altogether to $3,075,762, as follows:

Act of July 2, 1884	$500,000	
" " March 3, 1885	84,000	
" " July 26, 1886	343,000	
" " Aug. 3, 1886	1,000,000	
" " March 3, 1887	1,128,362	
" " " " (for three steel cast guns)	20,400	
		$3,075,762

The appropriations for armor are as follows:

Act of March 3, 1885	$25,000
" " March 3, 1887 (armor and gun steel)	4,000,000
	$4,025,000
Add appropriations for new vessels	21,522,350
Batteries, torpedoes, etc	2,150,000
Appropriation for armament, as above	3,075,762
Total appropriation for increase of navy	$30,773,112

Name or Type.	Displacement.	Battery.	Status.	Limit of Cost.	Act.	Speed, Knots.
Chicago	4500	4 8-in. and 8 6-in.	Fitting for sea at N. Y. Yard.	$1,576,854	Aug. 5, 1862.	15
Boston	3000	2 8-in. and 6 6-in.	Not yet commis	1,031,225	Aug. 5, 1882.	13
Atlanta	3000	2 8-in. and 6 6-in.	In commissio n	1,031,225	Au5. 5, 1882.	13
Dolphin	150	1 6-in.	In commission	460,000	Aug. 5, 1882.	15
Charleston	3730	2 10-in. and 6 6-in.	Under contr'ct	1,100,000	Mar. 3, 1885.	18
Baltimore	4413	4 8-in. and 8 6-in.	Under contr'ct	1,500,000	Mar. 3, 1885.	19
Newark	4083	12 6-in.	To be readv'd	1,300,000	Aug. 3, 1886.	18
Gunboat 1	1700	6 6-in.	Under contr'ct	520,000	Mar. 3, 1885.	16
Gunboat 2	870	4 6-in.	Under contr'ct	275,000	Mar. 3, 1885.	13
Double - bottomed armored vessel, cruiser No. 1	6000	4 10-in. and 6 6-in.	Plans not decidedon	2,500,000	Aug. 3, 1886.	17
Double - bottomed armored vessel, battleship No. 2	6000	2 12-in. and 6 6-in.	Plans not decidedon	2,500,000	Aug. 3, 1886. Aug. 3, 1886.	7 23
First-class torpedo boat	108	5 torpedoes & 2 mach. guns.	Plans not decidedon	100,000		
Puritan	6000	4 10-in.	Plans forcompletion ready but not adv't'd.	$3,178,046 for all five double-turreted monitors.	August 3, 1886.	14
Amphitrite	3815	4 10-in.	"			12
Monadnock	3815	4 10-in.	"			12
Terror	3815	4 10-in.	"			12
Miantonomoh	3815	4 10-in.	Nearly compl.			12
Dynamite Gun Cruiser (230 ft. x 26 ft.)	500	3 10½-in. dynamite guns.	Under contr'ct	350,000	Aug. 3, 1886.	20
Steel Cruiser No. 1	5000	To be determined.	Authorized.	1,500,000	Mar. 3, 1887.	19
Steel Cruiser No. 2	5000	To be determined.	Authorized.	1,500,000	Mar. 3, 1887	19
Steel Gunboat No. 1	1700	6 6-in.	Authorized.	550,000	Mar. 3, 1887.	16
Steel Gunboat No. 2	1700	6 6-in.	Authorzed.	550,000	Mar. 3, 1887.	16

There are also for "floating batteries, or rams and other naval structures to be used for coast and harbor defense," authorized by act of March 3, 1887, $2,000,000; the *Stiletto*, purchase authorized for experiment, $25,000; torpedoes for which the act of Aug. 3, 1886, appropriated $75,000 and the act of March 3, 1877, an additional $50,000.

Coast Defenses.

GENERAL H. L. ABBOTT delivered a lecture before the Academy of Sciences in New York, on the evening of March 21, a summary of which is given by the *Herald* as follows:

According to General Abbott the country needs for its coast defenses:

Heavy guns;
Armor-clad casemates;
Disappearing gun carriages in earthworks:
Heavy mortars;
Submarine mines or fixed torpedoes, and
Fish torpedoes.

The lecturer said that this nation may be attacked in four ways: First, by fleet and army combined, as in our Revolutionary War; second, by blockading the entrances to all our ports; third, by bombardment of our seaport cities from a long distance; fourth, by a fleet forcing its way into our harbors, and making a direct attack or levying tribute on our people.

The first is not now greatly to be feared. We are too distant from great powers, and too strong on land.

The second should be met by the Navy, and is, therefore, outside a discussion of coast defenses.

The third is not probable, though it may be possible. The extreme range of 10 miles for heavy guns cannot be obtained from shipboard, and as an elevation of only 15° or 16° can be given, not over 5 to 6 miles' range is attainable.

The fourth is the one which is possible, probable, even certain—if we have war before we have better defenses.

The race between guns and armor began about thirty years ago, and there has been more development in ships and guns in that time than in the two hundred preceding years. The jump has been from the 7-in. rifle as the largest piece, to the 110-ton Armstrong; in armor from 4½ in. of iron, to the *Inflexible* with 22 in. of steel plating. The new Armstrong gun of 110 tons, tried only last week, with 850 pounds of powder and an 1,800 pound shot can pierce all the targets, and so far guns have the victory over armor. This gun developed 57,000 foot-tons of energy, and will probably reach 62,000. Imagine the Egyptian needle in Central Park, shod on its apex with hard steel, dropped point downward from the height of Trinity steeple; it weighs 225 tons, and it would strike with just about the effect of one of the 110-ton gun's projectiles. Two of these guns are ready for the ironclad *Benbow*, and the Italians have several equally powerful of 119 tons from Herr Krupp. The most powerful gun in the United States, the 15-in. or the 12 in. rifle, has a muzzle energy of 3,800 foot tons.

Ships like the *Inflexible* are the most powerful afloat. A steel water-tight deck extends across the ship, and she has 135 water-tight compartments. Her guns and engines amidships have a protection of 24 in. of armor, and amidships she has a citadel carrying two revolving turrets, each containing two 80-ton guns. Her turret armor is 18 in. thick. She can make 14 knots, and she has cost $3,500,000. But she has a low free-board, and the guns therefore get no plunging fire.

The French ship *Meta* has her heaviest guns mounted *en barbette*, high above the water line, giving a splendi plunging fire.

Either of these ships could enter any of our harbors and hold us at her mercy.

The entrance to the harbor of Alexandria, Egypt, is about 5 miles across. At the time of the bombardment the protecting fortifications were situated at the east end, in the center, and at the west end. On the west there were mounted 20 modern guns of great size and power, and there were 7 others at the east end.

Although the Egyptians fought bravely they did very little harm to the English fleet, while on the second day the defense was silenced altogether. Following the bombardment—as in Paris—came the reign of mob law, doing more harm than the shells had done; and it is a possibility that every such bombardment would be followed by such an overthrow—at least temporary—of all forms of law and order.

The ships that had silenced the Alexandria batteries—which had 27 heavy guns more than we have—could reach our coasts in 10 or 12 days, and we would have nothing to meet them.

Armor-clad casemates are beginning to take the place of masonry. A tremendous thickness of masonry is built up to the very embrasures for the guns in the steel-clad turrets. This (the Gruson) system has been adopted by Belgium, Holland, Germany, Austria and Italy.

In 1882 England had 434 heavy modern guns behind armored shore batteries; besides these at home, she had 92 in her colonies, of which 13 were in Halifax and 11 in Bermuda—for our express benefit.

What we have are brick and stone casemates and earthworks. A sample granite casemate, with iron-lined embrasure, was built at Fortress Monroe, and 8 shots were fired at it from a 12. in. rifle converted from an old 15. in. smooth bore. This gun develops only 3,800 foot-tons of energy—a mere nothing compared with the 62.000 foot-tons of the English and German 110-ton guns.

General Abbott showed most conclusive proof of the

worthlessness of masonry forts in pictures showing the effect of the shots. The massive 8 ft. thickness of granite was pierced and battered till it looked like a ruin. Not a man inside would have been left alive.

He also showed a "disappearing" gun in an earthwork, the gun recoiling below the level of the parapet and being run up to a firing position by a counterweight. In 1878 Congress stopped all appropriations for defenses, and nothing had been done since.

General Abbott said that we needed submarine mines or fixed torpedoes which should be thickly interspersed about the channel and be exploded by an electric battery on shore. To prevent these torpedoes from being exploded by the enemy the surface over them should be covered by plenty of guns. Heavy guns and mortars were needed to resist attacks by heavy iron-clads. Movable torpedoes were valuable, but only as an auxiliary—a very minor auxiliary—compared with submarine mines. We should be cautious not to infer that torpedoes made a satisfactory defense alone, as they must be protected by large and small guns, and they form only a part of the chain of general defenses.

The English 110-Ton Gun.

(From *Engineering*.)

FOR some months past visitors to the Royal Arsenal, Woolwich, may have noticed, lying near the great steam crane of the gun factories two large guns, within a fraction of 44 feet in length, and each weighing 247,795 pounds, or rather over 110½ tons. One of these pieces of ordnance—the largest ever made in this country—last week commenced its firing trials at the proof butts, under the personal supervision of Colonel Maitland, R. A., Superintendent Royal Gun Factories, and in the presence of the President and some of the members of the Ordnance Committee; Captain Andrew Noble, C. B., and of Mr. Vavasseur representing the Elswick Ordnance Company.

We shall in an early issue give illustrations of the new gun, and shall compare it with the 119-ton Krupp gun, but meanwhile we may give some leading particulars. The gun is made throughout of steel; the "A" or inner tube is made in one length from a forging supplied by Sir J. Whitworth & Co., instead of being in two parts, as in the Italian heavy guns, made also at Elswick. Over the inner tube is shrunk the breech-piece, which is supported by three layers of comparatively thin steel hoops. It will thus be seen that the whole of the metal assists in bearing the transverse strain, but the inner tube is free from any portion of the longitudinal strain, as it extends only to the "obturator;" the breech-piece takes the greatest part of that strain, but it is assisted therein by the peculiar construction and distribution of the hoops. A long hoop with stout shoulders forms the rear part of the first layer, and its front exterior shoulder engages the rear shoulder of another long hoop, which forms the front part of the second layer. Again, the "trunnion hoop" (so called) is formed and shrunk on in such a manner as to draw the long hoops of the first and second layers together; hence there is a direct pull from the trunnion hoop to the shoulder on the breech-piece. There are in reality no trunnions, the exterior of the trunnion hoop forming rings which will be held in a strong steel band attached to the gun slide in the barbette battery of the ship. To prevent the inner tube moving forward inside the breech-piece, a ring of a bronze alloy is run into a serrated recess at the front of the latter; a similar ring is used to assist friction in keeping the front of the trunnion hoop in its place.

The hoops are all so arranged as to break joint, and an ingenious plan is adopted to link together, by means of the outer one, those hoops which abut against one another. This consists of rings on the exterior and interior of the inner and outer hoops respectively, alternate portions of which rings are slotted away; the outer hoop, when heated, is passed over the inner, so that the projections left pass through the slotted intervals, and it is then turned round till the projections of one hoop engage exactly with those of the other. No longitudinal movement is now possible, and the intervals are all filled up with steel wedges, so that there can be no circumferential shift. Thus the gun is bound together from the extreme breech end to a point far up the chase.

It may be noted that, in the French heavy guns, the breech-screw engages in the inner tube itself, which thus becomes almost wholly responsible for the longitudinal strain. Again, in Krupp's great 119-ton gun the longitudinal strain is entirely taken by the end of the breech-piece, which supports the back of the wedge closing the bore; it is moreover weakened by the loading hole through its rear end.

The "obturation," or means of stopping the escape of powder gas, is peculiar to this gun. It is not the Elswick cup nor the De Bange asbestos pad, but a modification introduced by Mr. Vavasseur, wherein the mushroom-head of the De Bange pad is retained, but the asbestos is replaced by a ring of soft copper which is forced by compression, on the discharge of the gun, into close contact with the inner tube; no ring is required to be inserted inside the end of the bore.

The principal dimensions of the 110-ton gun are as follows:

Total length	524 in.
Length of bore (30 calibers)	487 in.
" rifling	397 in.
Diameter of bore	16.25 in.
" chamber	21.125 in.
Cubical capacity of chamber	28,610 cub. in.
Weight of gun	247,795 lbs.
" projectile	1,800 lbs.

The polygroove rifling commences with one turn in 120 calibers and increases to one turn in 56 calibers at the muzzle.

The gun was carried down to the proof ground, as well as fired upon, the ingenious bogie carriage—running on six pairs of steel trucks—constructed in the Royal Carriage Department, under General Close, the steel castings being supplied by Messrs. John Rogerson & Sons, Stanners Close Works, Wolsingham. It weighs 95 tons, and is so constructed that it can be altered to mount for proof all the heavy breech-loading guns from the 12-inch of 43 tons upward. The carriage is free to run back on the inclined rails, when fired, returning again to the loading point by its own weight; but the chief force of recoil is taken by the Vavasseur hydraulic buffers, the ends of the pistons being fixed on the carriage, while the cylinders are free to move with the gun slide.

It was about noon before the firing commenced, the service of the gun being very slow, owing to the operations of loading, etc., which will ultimately be performed with the greatest ease by means of hydraulic gear, having at present to be carried out with ordinary tackle by hand. The charges of powder commenced at 600 lbs. of Waltham Abbey "prism brown," commonly called "cocoa" powder; each charge was subdivided into sections of about 112 lbs. or 150 lbs. for convenience of loading, the prisms being arranged as usual in rigid hexagonal cartridges cased in silk cloth. The proof cylinders weigh 1,800 lbs., as will the service projectiles, all of which will be made of steel; the armor-piercing projectile will be of forged steel, probably made on the Firminy plan, the others being common shell and shrapnel. The report of the gun was not so loud as might have been expected, owing, probably, to the slow-burning powder used and the length of the bore, but the addition of each 100 lbs. of powder made a very appreciable difference in this respect.

The recoil of the hydraulic cylinders on the slide at the first round was about 4 ft. in addition to which the gun and carriage ran back on the inclined rails from 50 ft. to 60 ft.; in the second and third rounds the recoils on the slide were 4 ft. 9 in. and 5 ft. 6 in., and the distances traveled back on the rails 69 ft. and 77 ft. respectively. The fourth round (which was fired on Wednesday last) was fired with 850 lbs. of Westphalian powder, "Prismatic No. 1 Brown," the prisms measuring 1¼ in. from face to face and 1 inch in length. The explosion proved to be quick, and sent the powder pressure up to 18¾ tons, or 2¾ tons higher than was anticipated. The highest

service pressure is intended to be 17 tons, so that this has already been exceeded in the trials. The muzzle velocity was not increased in proportion to the pressure, and only reached 2,078 ft. per second. The recoil of the gun on its carriage was 3 ft. 3 in., the hydraulic buffer being set to a greater resistance than before, and the run on the rails was about 70 feet.

The corrected muzzle velocities and the mean pressures in powder chamber are given in Table A, below, together with the total energy at muzzle, and the energy per ton of gun—the latter proportion being a very important consideration in naval ordnance.

On the first day only one round had been fired before the men's dinner-hour, and the gun was not loaded for the second time until 3 P. M.; owing to the accurate observations which had to be taken after each shot, as well as to the slowness of manipulating such masses of metal by hand, it was nearly 5 o'clock before the firing was suspended for the day. Upon careful examination at the end of the three rounds the interior of the inner tube was found to be perfectly clean and uninjured.

It is intended to continue the experimental proof of this gun with successive charges of 900 lbs., 925 lbs. and 950 lbs., or such of them as can be fired until the intended limit of pressure in the powder chamber is reached. It is hoped that a muzzle energy bordering upon 62,000 foot-tons may be attained with the full charge. The powder charge of 850 lbs. was the largest ever hitherto fired from a gun in this country, although the Elswick 104-ton gun for the Italian Government was fired at Spezzia with some 50 lbs. more; the projectiles were virtually of the same weight, but the muzzle velocity then attained was only 11 feet per second higher than that given by the third round of the 110-ton gun with 100 lbs. less powder.

In Table B are the comparative results (so far as they are known) given by the heaviest guns in the possession of the chief European naval powers, with those already obtained from the 110-ton gun.

TABLE A.—*Showing Results of Firing 110-Ton E. O. C. Gun.*

No. of Round.	Weight of Powder Charge.	Weight of Projectile.	Muzzle Velocity.	Mean Pressures.	Total Energy at Muzzle.	Energy per Ton of Weight of Gun.
	lbs.	lbs.	feet per second.	tons per square in.	ft. tons.	ft-tons.
1	600	1800	1699	9.65	36.050	328
2	700	1800	1843	12.05	42.390	385
3	800	1800	2007	15.00	50.260	457
4	850	1800	2078	18.75	53.927	490

NOTE.—Round No. 3 would give a power of perforating about 30 in. of iron at 1,000 yards distance.

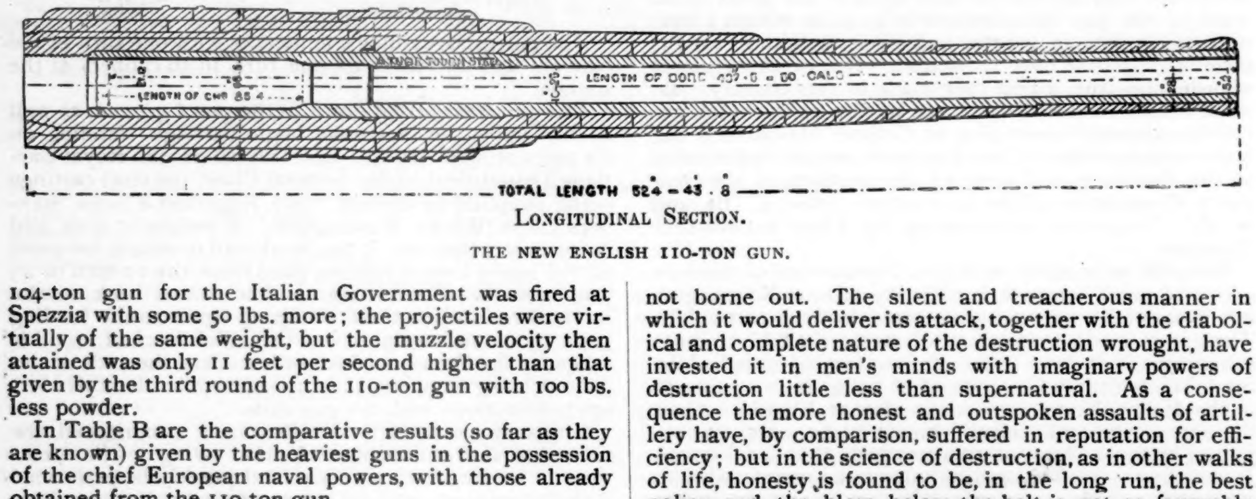
TABLE B.

Nature of Gun and Caliber.	Weight of Gun.	Powder Charge.	Weight of Projectile.	Muzzle Velocity.	Total Muzzle Energy.	Perforation of Iron at 1,000 Yards.	Energy per Ton of Gun.
	t'ns	lbs.	lbs.	ft. per sec'd.	foot-tons.	in.	foot t'ns
French, 37 cm. (14.56 in).........	71	546	1180	1955	31272	24.5	440
German (Krupp), 40 cm. (15.75 in.)	71	485	1715	1703	34502	23.8	486
" " " "	119	615	1632	2017	46061	29.2	387
Italian (Elswick), 43 cm. (17.00 in.)	104	899½	1799	2018	50810	29.5	488
English (R. G. F), 13.5 in.......	67*	625	1250	2050	36415	28.6	569
" Elswick 16.25 in........	110	850	1800	2078	53927	33.0	490

* The results of this gun are estimated only.

NOTE.—The Russian and Austrian guns are on the Krupp system, but less powerful than those given above.

Table B shows the very favorable performance of the newest English gun as compared with the Krupp. The length of bore in the former is very nearly as great as in the latter, the extra length over all being necessitated by the projecting breech-piece of the Krupp system, which also accounts for a great part of the additional weight. It is to be noted, however, that the largest charge of powder hitherto fired (so far as we are aware) in the Krupp 119-ton gun is a very light one compared with that which has been fired already in the Elswick guns; also, that the heavy German gun has been ordered by the Italian Government for coast defense. We are indebted to Lord Brassey's *Naval Annual* for most of the above figures concerning foreign guns. The illustrations given herewith are a longitudinal section of the gun, and diagrams of H. M. S. *Benbow*, for which the 110-guns are intended. These show the method of barbette mounting. The central part only of the vessel is armored, and the ends of the vessel are protected by an armored deck below the water line.



LONGITUDINAL SECTION.

THE NEW ENGLISH 110-TON GUN.

Gunboats.

(From Engineering)

THE unknown and generally overrated powers of offense of the fish torpedo have given that weapon a character as an engine of destruction which recent experiments have not borne out. The silent and treacherous manner in which it would deliver its attack, together with the diabolical and complete nature of the destruction wrought, have invested it in men's minds with imaginary powers of destruction little less than supernatural. As a consequence the more honest and outspoken assaults of artillery have, by comparison, suffered in reputation for efficiency; but in the science of destruction, as in other walks of life, honesty is found to be, in the long run, the best policy, and the blow below the belt is not so favorably looked on as it was some short time ago.

Under these circumstances Sir George Elliot has chosen his time well, for advocating the more extended use of gunboats in coast-defense tactics; for, although the torpedo has never wrested from the gun its premier position, so far as large vessels were concerned, it has had things very nearly all its own way with the smaller kind of craft. The paper which the gallant Admiral read at the Royal United Service Institution last Friday had the serious defect of wandering very far from the subject matter of its title. It would, perhaps, be too much to expect Sir George Elliot to discourse for any length of time about ships without fighting over again the battle of the *Waterwitch* and the question of hydraulic propulsion. But although one may be willing to grant him the indulgence of this amiable weakness, it is taking rather a wide range to discuss our whole naval policy, both from a political and economic point of view, under cover of Gun boats for Coast Defense.

Having said this we have little but praise for the paper in question, and although the greater part of it was not germane to its title, yet the strictures of the author on political meddling in naval matters might well be read by every one of Her Majesty's subjects; more especially all those close-fisted and short-sighted tax-payers who grudge the expense of our national insurance, the chief premiums of which are the ships of the Royal Navy.

We must not, however, be led astray by the author's bad

example, but will at once proceed to consider some of the most important facts respecting coast defense by gunboats, as set forth in the paper.

The author commenced by speaking of the notable services rendered by gunboats in past times, referring to James's "Naval History," and then puts the question "whether modern inventions have, in any degree, affected the essential value of this class of vessel for coast defense, either by the introduction of steam, armor-plating, submarine mining, rifled guns of greatly increased caliber, or quick-firing or machine guns, by the substitution of vessels of the *Glatton* type, by torpedo boats of various types and dimensions, or by a combination of all or any of these appliances for purposes of inshore defensive operations?" The gallant Admiral at once proceeds to answer his own question in the negative. "I am unable to perceive," he says, "that the modern gunboat has been supplanted by any of these novel features, or has lost any of its effective power for warding off attacks by bombardment at long ranges, whether by single ships or small squadrons; and, in fact, whatever advantages have been obtained on the one side, are equally applicable to the other." Indeed, Sir George goes further than this, for he says later on: "It would appear that owing to the reduced number of guns which modern ships now carry, and the long ranges at which the stoutest ships are now penetrable by guns which can be mounted in gunboats, and with the introduction of the latest invention of shell projectiles, that the gunboat of the future has rather gained than lost."

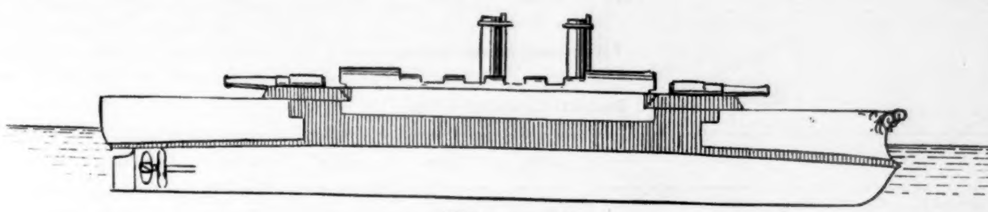
Armor-clad ships may be less vulnerable than the old wooden vessels, but the same remark applies, as the author pointed out, to shield-protected gunboats fighting end-on, and the smaller object will still retain its distinct advantages. Sir George Elliot would not, however, wish to disparage the value of shore batteries, submarine mines, or torpedo boats, but thinks that these means of defence would prove inoperative in the absence of assistance from gunboats, so far at least as preventing the bombardment of many of our seaport towns from distances of four to five miles.

The question, like all others of national defence, is based on expenditure. How to get most for our money is what must guide our decisions. This the author fully recognizes, and upholds his position chiefly on the score of economy. It has been contended that an outlay on additional warships equal to that demanded for gunboats stationed round the coast, would give a more efficient means of protection. This opinion, Sir George acknowledges, presents itself with a certain amount of force at first sight, but even if true in some respects, there is always the fatal objection that powerful seagoing ships might be enticed away, and they would not possess the advantages, for inshore fighting, of shallow draught. Sir Andrew Clark advocates seagoing torpedo vessels, very swift, but completely unprotected and lightly armed. In spite of the lower cost of such craft compared to armored gunboats, Sir George Elliot stands by the latter, because the vulnerable torpedo vessels could be disabled in detail by gun-fire, as a ship at sea would naturally turn her stern to approaching torpedo boats, and keep them under fire as long as possible, and when ships are moving in the same direction, the striking range of the torpedo is almost reduced to close quarters.

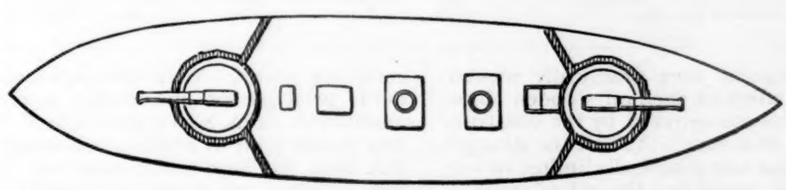
The author advocated two classes of gunboats for the purposes under discussion. The first class should possess considerable speed, and would be designed to take the place of vessels of the *Glatton* type; whilst the second class would be for purely local defence where a high rate of speed would not be essential. Both classes should be armed with one very powerful armor-piercing gun, protected by a semicircular shield of stout armor-plating for end-on fighting, besides carrying a number of quick-firing and machine guns for defence against torpedo boats. The first class should have two military masts. The smaller vessels, roughly of about 800 tons displacement, would work in close vicinity to the land, and would not require a speed above 12 knots. Their tactics would be to advance a few thousand yards from the shore, and always retire if pursued. The larger class would be about double the size and mount a 12-in. breech-loader, 43-ton gun. They would be stationed at different ports, ready to concentrate at any point threatened. The vessels would operate as widely as safety would permit, so as to operate if possible from opposite directions of fire, and thus obtain a broadside attack.

The problem of manning such craft led to some remarks on the naval volunteer question; but without following the author and other naval officers, who spoke afterwards, it may be sufficient to say that this body has evidently won the high esteem of the regular service by the efficiency and zeal they have displayed under somewhat discouraging conditions, due principally to want of an adequate chance of learning their duties.

The discussion which followed the paper was not worthy of the occasion or the Institution. The subject is so essential a one for the service, that one might have hoped naval officers would have attended, in order to give their views and help those who have the settling of such matters to form an opinion as to the soundness of the author's contentions. As a matter of fact, there was little, if anything, said of a critical nature, so far as the ostensible object of the meeting was concerned; the old dreary controversy on hydraulic propulsion, with all the stock arguments hashed up afresh, occupying the greater part of the time. The one bright feature in the discussion was the admirable manner in which the Chairman, Admiral Sir E. Fanshawe, carried out his duties.



ELEVATION.



PLAN

H. M. S. "BENBOW," ARMED WITH 110-TON GUNS.

Modern War Ships.

The report of the lecture on this subject, which was published in the last number of the JOURNAL, did not give some very interesting tables which have been published in *Industries*, and which are given below. To make their significance understood, the abstract of the lecture given by our cotemporary is reprinted, although most of it was contained in the report which was published last month:

In 1859 the Admiralty were forced to action by the French, whose navy, under the skillful superintendence of M. Dupuy de Lome, had outstripped our own. In that year 17 line-of-battle ships and 10 frigates were fitted with engines and propellers; but the enormous sums expended on these conversions were practically wasted, owing to the shattering effect of shell on wooden ships, and in 1861 a new type was inaugurated by the construction of the *Warrior* and *Minotaur*. At first the struggle between attack and defense was practically limited to one between guns and armor; ramming—the other mode of attack—exercised but little influence on ships' designs, as it only necessitated stronger and differently shaped bows and water-tight compartments. By the 4½-in. armor of the *Warrior* the defense scored a victory; but this did not last long, and at the present day the power of the guns, in comparison with the resistance of the armor-plating, is greater than it has ever been before. In illustration of this, Mr. White referred to the figures in the accompanying table respecting English naval guns.

MUZZLE-LOADING GUNS.

	68 pr.	*110pr.	6½ ton.	12 ton.	18 ton.	25 ton.	35 ton.	38 ton.	80 ton.
Extreme length	10 ft.	10 ft.	11 ft.	13 ft.	15 ft.	15 ft.	16 ft. 3 in.	18 ft. 7 in.	26 ft. 9 in.
Caliber, inches	8	7	7	9	10	11	12	12½	16
Powder charge, lbs	16	12	30	50	70	85	140	210	450
Weight of projectile, lbs	68	110	115	256	410	548	714	820	1700
Energy at 1000 yds. in foot-tons	452	...	1280	2840	4400	5840	8050	11900	26370
Penetration of unbacked wrought-iron at 1000 yds	...	5 in.	7.3 in.	9.9 in.	11.7 in.	13 in.	14.6 in.	17.7 in.	23 in.

* Armstrong breech-loader.

BREECH-LOADING GUNS.

	2 ton.	5 ton.	14 ton.	22 ton.	45 ton.	67 ton.	110 ton.
Extreme length	11 ft. 7in.	14 ft. 5½ in.	21 ft. 2½ in.	25 ft. 10 in.	27 ft. 4½ in.	36 ft. 1 in.	43 ft.
Caliber, inches	5	6	8	9.2	12	13½	16¼
Powder charge, lbs	16	55	115	175	315	520	900
Weight of projectile, lbs	50	100	210	380	710	1250	1800
Energy at 1000 yds in foot-tons	735	2120	5580	9310	18150	29500	54000
Penetration of unbacked wrought-iron at 1000 yds	6.7 in.	10.9 in.	15.5 in.	18.4 in.	22.5 in.	27 ft. 2 in.	35 in.

Between 1859-73 the most notable changes in ship designs were due to the desire to secure fewer and heavier guns, and thick armor on as restricted a surface as possible. Thus the *Warrior* had her ends unarmored, and, though bearing 40 guns, could not sweep the horizon, and to obviate this disadvantage the *Minotaur* was armored from end to end. To avoid the addition of the extra 1,800 tons of 5½-in. armor, necessitated by this plan, the *Bellerophon* and *Hercules* were built on the "belt and battery" system, in which 12 and 14 guns respectively were carried in a box battery amidships, with outlying armored batteries at bow and stern. The *Devastation* followed, in 1869, on the "breastwork monitor type," with a low freeboard, armored from end to end in the region of the water-line, and bearing two 35-ton guns, in a central revolving turret. With the *Inflexible* the "central citadel's" principle was introduced, in which, the ends being unarmored, 24 in. armor was secured for the citadel, the four 80-ton guns in which could sweep the whole horizon. But here the high-water mark of "concentration" had been reached, and a reaction, headed by the French, and supported by the Italians, soon set in. To take advantage of the special weakness in our low freeboard ships, the French mounted their heavy guns *en barbette* high above the water, and associated with them many lighter guns. In the *Italia* and *Lepanto* the Italians followed the same plan, and mounted their four 100-ton guns 20 ft. higher above the water than the turret guns in our low freboard vessels. To meet these the *Admiral* class was designed in 1880, in which the key of the design consists

	Warrior.	Minotaur.	Bellerophon.	Hercules.	Devastation.	Dread-nought.	Inflexible.	Colossus.	Colling-wood.	Benbow.	Camper-down.	Trafalgar.
Date of design	1859	1861	1863	1866	1869	1872	1874	1878	1880	1882	1882	1885
Length of ship in feet	380	400	300	325	285	320	320	325	325	330	330	345
Breadth of ship	58 3	59 3	56	59	62 3	63 10	75	68	68	68 6	68 6	73
Load displacement in tons	8820	10280	7270	8680	9300	10820	11880	9150	9150	10000	10000	11940
I. H. P.	5500	6900	6500	8500	6600	8000	8000	7000	9600	11500	11500	12000
Speed in knots at load displacement	14.4	14.3	14.1	14.7	13.8	14.2	13.7	15.4	16.7	17.0	17.0	16.5
Number of guns	40	50	14	12	4	4	4	9	10	12	10	12
Heaviest gun	110 pr.*	110 pr.*	12 ton R.M.L.	18 ton R.M.L.	35 ton R.M.L.	38 ton R.M.L.	80 ton R.M.L.	45 ton B. L.	45 ton B. L.	110 ton B. L.	67 ton B. L.	67 ton B. L.
Caliber of gun in inches	7	7	9	10	12	12½	16	12	12	16½	13½	13½
Powder charge, lbs	12	12	50	70	140	130	450	315	315	900	520	520
Weight of projectile, lbs	110	110	256	410	714	820	1700	714	714	1800	1250	1250
Total weight of armor, tons	980	1780	1090	1340	2540	3260	3280	2410	2520	2900	2940	4230
Weight of horizontal armor in decks, glacis plates, etc.	Nil.	Nil.	Nil.	Nil.	560	680	970	790	905	1155	1135	1040
Greatest thickness of side armor	4½	5½	6	9	12	14	24	18	18	18	18	20
Ratio.—Total weight of armor. Displacement of ship	.111	.173	.151	.154	.278	.296	.272	.263	.275	.290	.294	.352

* Armstrong.

of the principle of "distribution" of the main armament instead of concentration, and the association therewith of a powerful secondary battery. The following table further enforces the justice of the generalization that the gun is the most influential factor in modern war-ship design:

The lecturer then referred to the difficulty of supporting the enormous weights of these turrets, which, in the *Renown*, will be a movable weight of 850 tons concentrated on a circle 36 ft. in diameter, and surrounded by a redoubt weighing about 800 tons. In the *Italia* and *Lepanto* the barbette gun mountings, carried to a height of 33 ft. above water, weigh more than 2,000 tons. After predicting a great future for quick-firing guns, the speaker called attention to torpedo-boats, and said he thought in future none would be built between the 70-ft. launches that can be hauled on board, and those of the *Archer* and *Scout* classes of over 1,300 tons. Mr. White then referred to the elaborate fittings in first-class modern war-ships, and pointed out that they are provided with from 80 to 100 separate water-tight compartments, 31 hydraulic engines, and 45 auxiliary steam engines. Attention was next directed to the greatly increased speed recently attained. From 1859 to 1875, 14 knots was almost a standard speed for large ships; but now vessels of 13,800 tons run at 18 knots, cruisers at 18 to 20 knots, and torpedo craft at 19 to 25 knots. The lecturer then referred to the cost of war-ships, which had steadily risen from £70,000 for a 100-gun line-of-battle ship to £375,000 for the *Warrior*, £480,000 for the *Minotaur*, £360,000 for the *Devastation*, £620,000 for the *Dreadnought*, and £810,000

	Ironclad, 10,000 tons.		Cruisers.			
			3300 tons.		1500 tons.	
I. H. P.	Speed.	Increase of speed for 1000 i. h. p.	Speed.	Increase of speed for 1000 i. h. p.	Speed.	Increase of speed for 1000 i. h. p.
1000	8.3	...				
2000	10.6	2.3				
3000	12.0	1.4				
4000	13.3	1.3	10.4	...	12	...
5000	14.2	.9	13.0	2.6	14.8	2.8
6000	14.9	.7	14.6	1.6	16.3	1.5
7000	15.4	.5	15.8	1.2	17.2	.9
8000	15.8	.4	16.7	.9	17.9	.7
9000	16.15	.35	17.5	.8	18.4	.5
10,000	16.45	.3				
11,000	16.75	.3				
12,000	1.70	.25				

for the *Inflexible*. In the last mentioned the armor-plating cost £170,000, the propelling machinery £126,000, and the hydraulic gun-mounting and auxiliary engines £55,000. The *Benbow* and the *Renown* are each estimated to cost about £720,000, and the *Trafalgar* and *Nile* £860,000 each. To illustrate the ever-increasing difficulty of attaining higher speeds, the above table was given.

The Power Required to Move Slide-Valves.

[Paper Read at the Chicago Meeting of the American Society of Mechanical Engineers, by Mr. C. M. Giddings, Massillon, Ohio.]

THE investigation as to the amount of power required to move slide-valves has been, like most all mechanical researches, a matter of slow growth. The writer has sought in vain for this desirable information in many of the best authorities on steam engineering, and has found only various and elaborate deductions on a purely theoretical basis on the one hand, or else the individual opinion of over-sanguine inventors of slide-valves on the other hand, whose opinions, by the way, were entirely unsupported by tangible facts or experimental data of any kind. He determined, therefore, some time since, to enter the field of experimental research, with a view of finding, if possible, just how much power was consumed in moving the slide-valves of different engines, and how much that power varied under different working conditions; such as variations of speed and pressure, changes of load and variation in point of cut-off.

The first attempt of an experimental nature resulted in the device illustrated in fig. 1, which clearly shows the construction. Water or oil used on either side of the piston to transfer the pressure through a stop-cock to the indicator for recording in the usual manner. After having used this, it was learned that a similar device was tried by Dean Bros., the pump-makers of Indianapolis, but without success. This device was first intended to be used with a pressure gauge, but at the suggestion of Mr. Harris Tabor, an indicator was put on to register the variations of pressure in the cylinder, but the leakage past the indicator piston from the continued action of the engine soon produced a displacement which distorted the action of the valve and reduced the travel. The indicator was then displaced by a diaphragm gauge of low pressure, which had the end of the index sharpened and turned at right angles to the dial. The glass having been removed, this gauge was screwed in the cylinder where a stop-cock is now shown, and a stationary rest provided to support the slide, which carried a smoked glass. This was provided to avoid the friction of a pencil on paper, and when the glass was brought in conact with the vibrating point of the index, it described an outline on the glass which was easily preserved by blue printing, and could be made to

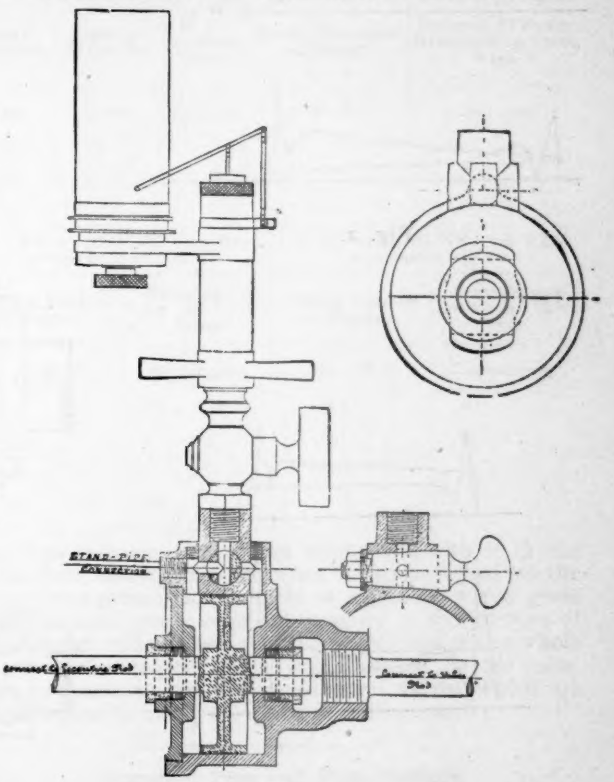


Fig. 1.

show fairly well the relative power required to move the valve under varying loads. These cards were found to be unworthy of entire confidence, for various reasons. The movement of the index was radial instead of rectilinear, and developed considerable momentum; one-half of the stroke only could be taken at once, and in spite of all precautions displacement would soon show its effects in reducing the travel of the valve when running at rated speed. However imperfect this device and its results, it was a decided step in advance of previous experiments. Having thus found the desirable feature for a valve dynamometer, it was determined to design and construct one which should possess as many of these points as possible.

1. It must be sufficiently yielding to feel the variations of strains on the valve stem, and at the same time so nearly rigid that it would give a very small fraction less than the full travel of the valve as the showing, from a reduced travel or a distorted value action, would be entirely unsatisfactory. In other words, it must be rigid without being entirely rigid.

2. It must show accurately the strains on the valve stem

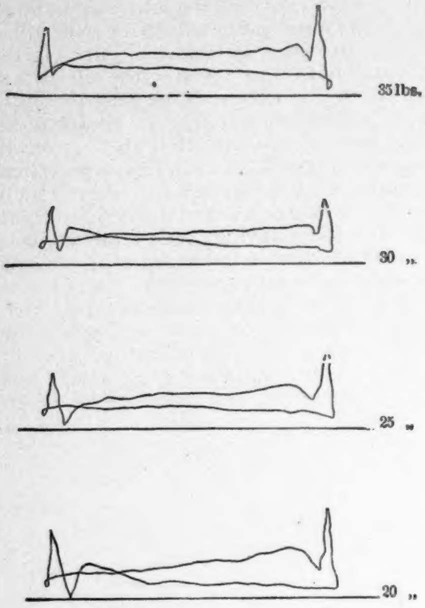


Fig. 2.

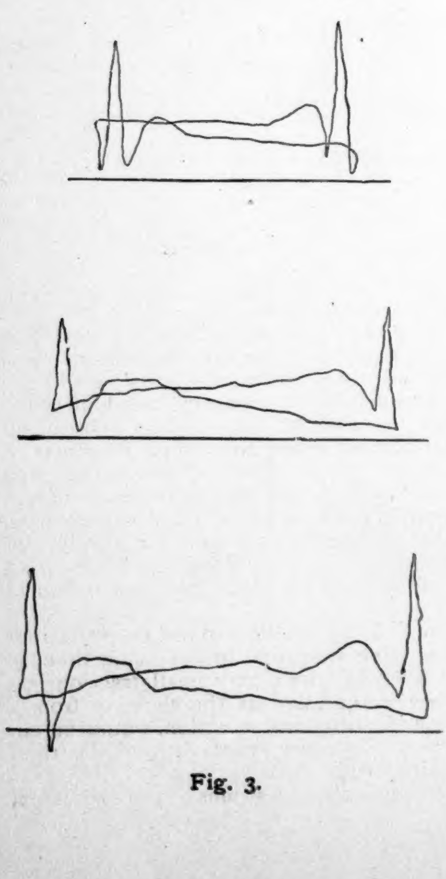


Fig. 3.

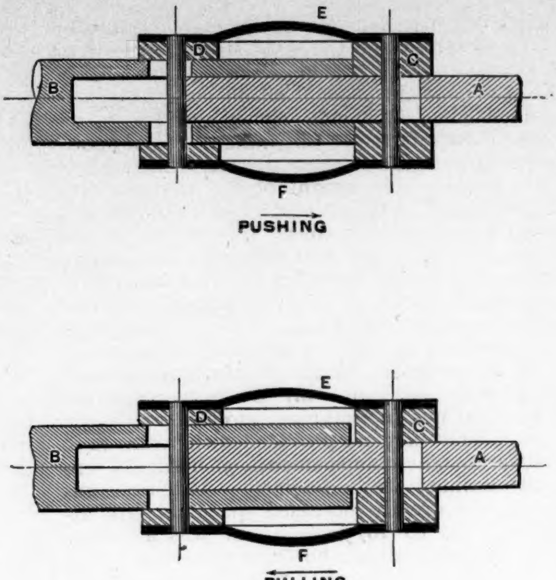


Fig. 4.

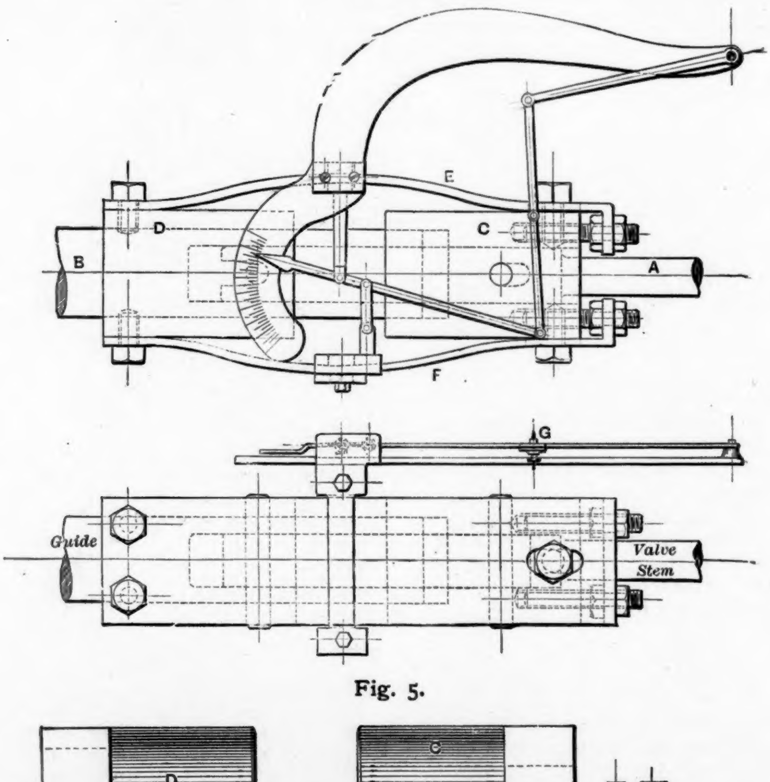


Fig. 5.

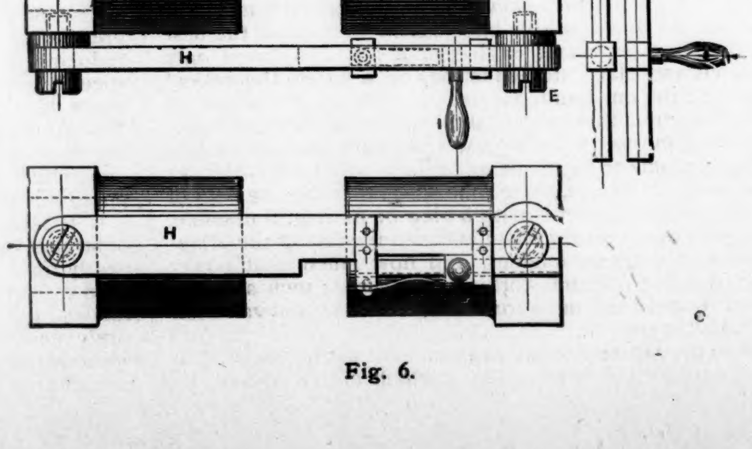


Fig. 6.

throughout the entire revolution of the eccentric, and *not simply* for one stroke of the valve. This, it is readily seen, would reverse the strains on the instrument.

3. It must have an accurate means of recording the variations of stress on the instrument, upon paper, for future calculations and comparisons of different valves.

4. It must be provided with a rigid connection to relieve the springs when not taking a card, with means to detach the same readily when under motion.

5. It must either have means of varying the tension of the springs for different size and type of valves, or be so constructed that the springs could be easily replaced with others of different tension.

The instrument designed to fill these requirements is shown in fig. 5. Fig. 4 shows in section the mechanical principles involved in the device, in which *E* and *F* are elliptical springs attached at their extremities to the sliding sleeves *C* and *D*. The former is the valve-stem guide to which the eccentric rod is attached, and the latter is the stem itself. To each spring suitable attachments are made for connecting the pivoted extremities of the parallel motion which carries the pencil *G*. A slide having suitable support was provided, which worked between grooves having an adjustable stop, so that the paper, mounted on the slide, could be brought in proper contact with the pencil and the stop properly adjusted. Then, in order to take a card, it is simply necessary to bring the paper in contact with the moving pencil during one complete revolution of the engine. A flat-pointed brass wire was attached to the instrument, so that when the paper was brought in contact with the pencil, this point would mark the neutral line, or line of *no* strain on the card, from which all measurements were taken.

It was a comparatively easy matter to design an instrument which would show the *pull* required by the valve, but when it came to showing the *push* required in the same instrument, it was quite another thing. Of course, it was impracticable to push on the ends of the springs, consequently the strain must be taken by the springs on the *pull* through *both* strokes of the valve. How this was done can best be shown by referring to fig. 4, in which corresponding letters refer to corresponding parts in fig. 5. *D* is a sleeve, sliding loose upon the valve-stem guide *B*, and attached to the springs; *C* is the sleeve sliding loose upon the valve-stem *A*. Each of the sleeves has a steel pin fixed in the sleeve, and passing through slots in the center of the valve stem and valve-stem guide respectively. It will be noticed that the valve-stem guide *B* comes to a bearing against the sleeve *C*; also that the valve stem *A* comes to a bearing against the pin in the sleeve *D*. When in operation the valve-stem guide first pulls the sleeve *D* by means of the pin, thence the strain is transferred through the springs to the sleeve *C*, which pulls the valve stem by means of its pin, as shown. But when it comes to the push part of the stroke, the valve-stem guide *B* first pushes against the sleeve *C* without moving the valve stem, thence the strain goes back through the springs to the sleeve *D*, which pushes on the end of the valve stem by means of its pin, and so moves the valve. Thus the strain always goes through the springs on the pull, and is then measured and recorded by the instrument.

The rigid connection shown in fig. 6 consists simply of the bar *H* hinged to the sleeve *D* and hooking over a post *E* on the sleeve *C*, and having a sliding catch *I* to hold it either on or off the post *E*. When this connection was locked in position, it was intended that there should be no movement of the pencil, but, owing to the spring of the parts, the pencil did move so that it could not be used to draw the neutral line. It was found that springs of this kind could be made stiff enough to move the valve without permitting any appreciable reduction of the stroke, and at the same time would be elastic enough to feel the slight variations of the strain, and produce sufficient movement when multiplied by means of the levers to make a good card. But this same quality prevented adjusting the springs equally for valves of different size, and it was decided to use springs of different thickness to meet this case.

A scale by which to measure the cards taken by the various springs was easily constructed by the use of a spring scale known to be accurate, and noting the movement of pencil for each 50 lbs. strain added to the dynamometer.

In computing these cards, the height gives the maximum, minimum and average strain on the valve stem in lbs. This, multiplied by the rate of movement gives the foot lbs. of work done to move the valve. In using this instrument, it was found that high speed produced fluctuations in the card, especially if the springs were too light for the valve, but with the proper strength of spring a speed of 250 revolutions per minute was entirely feasible. Fig. 2 shows cards taken with varying loads, and fig. 3 shows cards taken from varying points of cut-off. All cards taken with any considerable load invariably show one end (and that always the same end) heavier than the other. The cause of this for a time was a mystery, but was fully and satisfactorily explained by taking into consideration the area of the valve stem, which, multiplied by the pressure in the steam chest, worked against the instrument in one-half of the stroke and with it in the other half, making the difference in strain equal to the sum of the pressures. A table is appended which gives both the total power required to move a special type of equilibrium slide valve; also the percentage of the whole power of the engine which was absorbed by the valve. The comparative tables from different valves which are given herewith may perhaps be found instructive.

6¾″ BY 10″ ENGINE.

Revolutions.	Load on Brake, lbs.	H. P. to Move Valve.	Power Developed on Brake.	Per cent. of Power Developed on Valve Stem.
125	10 lbs.	$\frac{1}{16}$ H. P.	3 H. P.	2 per cent.
175	30 "	$\frac{1}{8}$ "	9 "	1.2 "
200	40 "	$\frac{1}{8}$ "	13.5 "	1.4 "

9″ BY 12″ ENGINE. 100 Rev. 3 PORTED FLAT VALVE.		9″ BY 14″ ENGINE. 100 REV. EQUILIBRIUM VALVE.	
Brake Load on Engine.	Percentage of Load on Valve Stem.	Brake Load on Engine.	Percentage of Load on Valve Stem.
5.5 H. P.	4½ per cent.	11.4 H. P.	1.2 per cent.
7 "	3½ "	13.5 "	1.1 "
8.25 "	4 "	14. "	1 "
8.9 "	6 "	15.6 "	1 "
11.1 "	7.3 "		

Standard Pipe and Pipe-Threads.

[From the *Stevens Indicator*, published at the Stevens Institute, Hoboken, N. J.]

THE chaotic state in which the matter of standard pipe-threads has been for years, both here and abroad, has finally had the effect of arousing American engineers at least to vigorous action. As a result the whole subject has been thoroughly overhauled by a committee appointed somewhat over a year ago by the American Society of Mechanical Engineers, in conjunction with committees of United States manufacturers of wrought-iron and boiler tubes, and brass and cast-iron fittings. The outcome of their work was embodied in an exceedingly interesting report submitted to the American Society of Mechanical Engineers at their last annual meeting (November 29–December 3, 1886), and which has just been issued in pamphlet form.

Without going into all the details which it was desirable to give in this report, it will suffice for our purpose to note that after an endless amount of correspondence, a large number of committee meetings, and the examination and test of many samples of threaded pipe, the several as-

sociations of manufacturers resolved to adopt and adhere to the original Briggs standard of gauges. Comprehensive information regarding the subject of standard pipe and pipe-threads as applied in American practice is given in the Excerpt Minutes of *Proceedings* of the British Institution of Civil Engineers (session 1882-83, Part I), containing the paper of the late Robert Briggs on American Practice in Warming Buildings by Steam. Referring specially, however, to the matter here considered, we take from the report before us the following, from the text and tables of Mr. Briggs's paper, giving completely the date upon which the Briggs standard pipe-thread sizes are based:

The taper employed for the conical tube-ends is uniform with all makers of tubes or fittings, namely, an inclination of 1 in 32 to the axis. Custom has established also a peculiar length of screwed end for each different diameter of tube. Tubes of the several diameters are kept in stock by manufacturers and merchants, and form the basis of a regular trade in the apparatus for warming by steam. The ruling dimension in wrought-iron tube work is the external diameter of certain nominal sizes which are designated roughly according to their internal diameter. These nominal sizes were mainly established in the English tube trade between 1820 and 1840, and certain pitches of screw-thread were then adopted for them, the coarseness of the pitch varying roughly with the diameter, but in an arbitrary way utterly devoid of regularity. The length of the screwed portion on the tube end varies with the external diameter of the tube according to an arbitrary rule-of-thumb; whence results for each size of tube a certain minimum thickness of metal at the outer extremity of the tapering screwed tube-end. It is the determination of this minimum thickness of metal for the tapering screwed end of wrought-iron tube which constitutes the question of mechanical interest.

For a tapering tube-end for a nominal 2½ in. tube—that is, a tube of about 2½ in. internal diameter and 2⅞ in. actual external diameter, the following particulars are given: The thread employed has an angle of 60°; it is slightly rounded off both at the top and at the bottom, so that the height or depth of the thread, instead of being exactly equal to the pitch, is only four-fifths of the pitch or equal to

$(0.8)\frac{1}{n}$, if n be the number of threads per inch. For the length of tube-end throughout which the screw-thread continues perfect, the empirical formula used is $(0.8\,D \times 4.8 \times \frac{1}{n}$ where D is the actual external diameter of the tube throughout its parallel length, and is expressed in inches. Further back, beyond the perfect threads, come two having the same taper at the bottom, but imperfect at the top. The remaining imperfect portion of the screw-thread furthest back from the extremity of the tube is not essential in any way to this system of joint, and its imperfection is simply incidental to the process of cutting the thread at a single operation. From the foregoing it follows that, at the very extremity of the tube, the diameter of the bottom of the thread is,

$$D-\left[\frac{2\times(0.8\,D+4.8)}{32\,n}+\frac{2\times 0.8}{n}\right]=D-(0.05\,D+1.9)\times\frac{1}{n}$$

The thickness of iron below the bottom of the thread, at the tube extremity, is empirically taken to be $=0.0175\,D + 0.025$. Hence the actual internal diameter d of any tube is found to be in inches,

$$d=D-(0.05\,D+1.9)\times\frac{1}{n}-2\times(0.0175\,D+0.025.)$$

or

$$d=0.965\,D-0.05\,\frac{D}{n}-\frac{1.9}{n}-0.05.$$

For the various sizes of tubes, ranging from ⅛ in. to 10 in. nominal internal diameter, with their corresponding numbers of screw-threads per inch, the actual internal diameter d is expressed by the following Table I in terms of the actual external diameter D.

Table I.—Diameters of Wrought-Iron Welded Tubes.

Nominal internal diameter of tube. Inches.	No. of screw threads per in. No.	Actual internal diameter d in terms of actual external diameter D. Inches.
⅛	27	$d = 0.9631\,D - 0.1204$
¼ and ⅜	18	$d = 0.9622\,D - 0.1556$
½ and ¾	14	$d = 0.9614\,D - 0.1887$
1, 1¼, 1½ and 2	11½	$d = 0.9607\,D - 0.2152$
2½ to 10	8	$d = 0.9587\,D - 0.2875$

The figures derived from this statement, which are of importance for practical use, are presented in detail in Table II in a convenient order for reference.

The number of screw-threads per inch for the several sizes of tubes is here accepted from customary usage. It is the workman's approximation of the pitch practically desired, and much reluctance must consequently be felt in calling it into question. Still it would have been better to investigate the general case upon the basis of a pitch ranging in closer accordance with the range of tube diameter. Thus the nominal ½-in. tubes might have had 16 threads per inch; ¾-in. 14 threads; 1 and 1¼-in. 12 threads; 1½ and 2-in. 11 threads; 2½ to 3½-in. 10 threads; 4 to 6-in. 8 threads; 7 to 9-in. 7 threads, and 10-in. not more than 6 threads per inch. The existing number of threads, however, as given in Tables I and II, are now too well established to be disturbed; at all events they must be taken in any statement of present practice.

Table II.—Standard Dimensions of Wrought-Iron Welded Tubes.

	Diameter of tube.			Screwed ends.	
Nominal inside.	Actual inside.	Actual outside.	Thickness of Metal.	Number of threads per in.	Length of perfect screw.
Inches	Inches	Inches	Inches	No.	Inches.
⅛	0.270	0.405	0.068	27	0.19
¼	0.364	0.540	0.088	18	0.29
⅜	0.494	0.675	0.091	18	0.30
½	0.623	0.840	0.109	14	039
¾	0.824	1.050	0.113	14	0.40
1	1.048	1.315	0.134	11½	0.51
1¼	1.380	1.660	0.140	11½	0.54
1½	1.610	1.900	0.145	11½	0.55
2	2.067	2.375	0.154	11½	0.58
2½	2.468	2.875	0.204	8	0.89
3	3.067	3.500	0 217	8	0 95
3½	3.548	4.000	0.226	8	1.00
4	4.026	4.500	0.237	8	1.05
4½	4.508	5.000	0.246	8	1.10
5	5.045	5.563	0.259	8	1.16
6	6.065	6.625	0.280	8	1.26
7	7.023	7.625	0.391	8	1.36
8	8.982	8.625	0.322	8	1.46
9	9.000	9.688	0.344	8	1.57
10	10.019	10.750	0.336	8	1.68

Taper of conical tube ends, 1 in 32 to axis of tube.

Revised Regulations for Steamboat Inspection.

At the recent annual meeting of the Board of Supervising Inspectors of Steam Vessels some changes were made in the rules governing inspections.

The following new paragraph was added to Rule II., Section 9: "Provided, however, that all lap-welded flues 16 in. diameter and not less than 7 in. diameter, when used under a steam presssure of 120 lbs. and upwards, shall be of the same thickness as prescribed in Table, Rule II., Section 8, for riveted flues."

Rule V., Section 5, is amended to read as follows: "No person shall receive an original license as engineer or assistant engineer, except for special license on small pleasure steamers, who has not served at least three years in the engineer's department of a steam vessel; provided, that any person who has served a period of three years as a locomotive or a stationary engineer, or as a regular machinist in steam-engine works at least three years, may be licensed to serve as engineer on steam vessels after having not less than one year's experience in the engine

department of a steam vessel of 20 tons or upward (which fact must be verified by the certificate, in writing, of the licensed engineer or master under whom the applicant has served), and no person shall receive license as above, except for special license, who is not able to determine the weight necessary to be placed on the lever of a safety-valve (the diameter of valve, length of lever and fulcrum being known) to withstand any given pressure of steam in a boiler; or who is not able to figure and determine the strain brought on the braces of a boiler with a given pressure of steam, the position and distance apart of braces being known; and no engineer or assistant engineer now holding a license shall have the grade of the same raised without possessing the above qualifications."

To Rule IX., Section 14, has been added as follows: "When it is known, or comes to the knowledge of the local inspectors, that any steam vessel is or has been carrying an excess of steam beyond that which is allowed by her certificate of inspection, it is recommended that the local inspectors in whose district said steamer is being navigated, in addition to reporting the fact to the U. S. District Attorney for prosecution under Section 4437, Revised Statutes, shall require the owner or owners of said steamer to place on the boiler of said steamer a lock-up safety-valve that will prevent the carrying of an excess of steam, and shall be under the control of said local inspectors.

"On the placing of a lock-up safety valve upon any boiler, it shall be the duty of the engineer in charge of same to blow or cause the said valve to blow off steam at least once in each watch of six hours, or less, to determine whether the valve is in working order, and it shall be his duty to report to the local inspectors any failure of such valve to operate.

"In case no such report is made, and a safety valve is found that has been tampered with, or out of order, the license of the engineer having such boiler in charge shall be revoked.

"It shall be the duty of the local inspectors to send a copy of this rule to every steamer in their district, when said copies are furnished by the department."

The rule in regard to wheel chains now reads as follows: "Masters and pilots of steamers on lakes and seaboard are required to have their wheel chains rove so that the wheel and helm shall move in the same direction, so that when the wheel is put to starboard the vessel's head shall go to port, and when the wheel is put to port the vessel's head shall go to starboard."

In regard to ascertaining the tensile strength of plates, the regulation now is that the test pieces from plates $\frac{5}{16}$ in. thick and less shall have an area of cross-section of $\frac{1}{4}$ sq. in.; for plates over $\frac{5}{16}$ in. and up to $\frac{3}{4}$ in. thick, the arc shall be equal in square inches to three-quarters the thickness of the plate in inches; for plates over $\frac{3}{4}$ in. thick the area shall be equal in square inches to one-half the thickness of the plate in inches.

The United States Weather Bureau.

(From *Science*.)

ALTHOUGH Congress has not ordered that the Weather-Bureau shall be transferred from the Signal Corps of the Army to some civil department, the steps that were taken towards the transfer give strong assurance that it will be made next year, when it can be undertaken more deliberately. The action was briefly as follows: the House bill No. 5190, to create a department of agriculture and labor, received several amendments in the Senate, among which the sixth had for its object the transfer of the weather-bureau from the Signal Office of the Army to the new department on July next. Although several senators voted on February 23 against this amendment, because they thought the action was too precipitate, it had a majority of 37 to 15, with 24 absent. It provided that the second lieutenants and the subordinate members of the corps should be transferred to the new department, without changing their work or their pay; that the rank of commissioned officers of the Signal Corps should not be affected by the transfer; and that the Chief Signal Officer should remain in charge of the bureau after the transfer until a director should be appointed for it. The bill then returned to the House, where, according to the reports we have received, it would have certainly been passed as amended, had not an unforeseen obstacle arisen. The President, it seems, does not desire an additional member in his cabinet; the bill was therefore referred back to the Committee on Agriculture by his friends in the House, and at this late date in the crowded session it could not again be reached, not being "privileged business." So the matter is dropped for the present.

This postponement is, on the whole, not to be regretted. It is quite clear that the failure to make the change was not due at all to a belief that it ought not to be made. Senator Edmunds offered the only considerable objection to the transfer during the debate on the amendment. It was clear to him "that the only way to have an effective organization is to have it under military control, so that a man cannot resign because he gets miffed about something, but he must do his duty." This mistaken impression found few if any supporters. It seemed to be generally understood that the loss of individuality and complete submission to authority, which constitute the essence of the military spirit, are out of place in a service that wisely makes open declaration of its need of intelligent personal action by calling on college graduates to enlist in it. Senator Dawes thought every one agreed that the service "ought to be transferred to the civil department of the Government," but believed that the transfer ought to be made more deliberately than was contemplated in the amendment. Senator Hale expressed the same views, and these two joined Edmunds and others in voting against the bill. But their favorable votes may be expected next winter, when perhaps less political and more appropriate surroundings may be chosen for the weather-bureau than it would have found in the proposed new department.

In the mean time the position of Chief Signal Officer is given to Captain Greely, who is thereby promoted to be a brigadier-general, the Senate having confirmed the President's nomination at the last moment. So great an advance in rank is unusual, and may be attributed in part to recognition of Arctic heroism,—for surely the preservation of a complete series of records under the most difficult and tragic circumstances was a splendid achievement,—and possibly in part to the feeling that the office should be given to some one already in the service, rather than to some colonel who stood, indeed, nearer in the line of promotion, but who had had no experience in the weather-bureau. But the failure of the deficiency bill makes the position of Chief Signal Officer an arduous one for the next year, for it is a thankless duty that involves reduction in some of the essentials of the service. It is to be regretted that the new Chief was not given at least the best opportunity of showing his powers. The remedy for unsatisfactory weather-predictions is not likely to be found while the service is thus embarrassed.

Limitations of the Expansion of Steam.

[From the *Journal* of the Franklin Institute.]

THE results of a mathematical investigation of the limitations of the expansion of steam, by Prof. William Dennis Marks, of the University of Pennsylvania, can be epitomized as follows:

We cannot expect, under the most favorable circumstances, to reach an economy which will surpass but very slightly one pound of coal per indicated horse-power per hour.

This would place 18 per cent. of the heat in coal as the extreme limit of its utilization. The condensation of steam occurs during its admission to the cylinder, and in some cases is surprisingly great.

The law of this condensation is as follows:

The condensation of the steam in the cylinder is proportional to—

1. The difference of temperatures of the steam at the point of cut-off, and while being exhausted.

2. To the area of cast-iron exposed to the entering steam up to the point of cut-off.

3. To the time of exposure of the interior surface of the steam cylinder to the exhaust steam.

4. The condensation is reduced by compression, subject to the same laws, but this is usually quite a small quantity.

The initial condensation of steam is due principally to the piston and cylinder heads.

The equilateral hyperbola approximates quite as closely as any other curve to the curve of expansion of steam in engines not embarrassed by a sluggish valve motion.

Compression will save some vaporous steam, but will not largely diminish the initial condensation because of its short duration.

Superheating is the most efficient expedient for economizing coal.

The steam jacket is not so efficient as is ordinarily assumed,

Slide valves are frequently the cause of large and unlocated losses.

The valves and pistons of steam engines are rarely steam-tight.

With properly designed compounded cylinders the ultimate expansion of the steam is a function of the ratio of the two cylinders.

The saving in compound engines is due to lesser initial condensation in the non-condensing cylinder.

From the physical properties of iron arises the necessity of, and advantage of, compound engines.

The beneficial effects of superheating, steam-jacketing and compounding, are more apparent in small than large engines.

The most economic ratio of stroke to diameter for steam cylinders is a function of the number of expansions, of the boiler pressure, of the exhaust pressure, and of the number of strokes per minute.

A large cylinder is more economical than an equal volume divided among small cylinders.

High rotative speeds demand shorter cylinders than are ordinarily used.

It is frequently, especially with high boiler pressure, the more economical to not use a condenser.

The throttling of steam, with an engine of fixed expansion and small cylinder, does not increase the consumption of coal per indicated horse-power per hour, but very slightly.

W. D. M.

The Mining Industries of China.

THE United States Consul at Hong Kong, in a recent report on the mining industries of China, says:—"The small advances made by the Chinese in developing and utilizing the mineral wealth of their country, mainly attributable to the innate hostility of the people and the government to any innovation on ancient usages and customs would appear to have received recently an impetus in the province of Kuantung, which justifies the expectation of impending progress. This is due mainly to the efforts and enterprise of Ho Amei, a native of Canton, who, after some years' residence in Australia, has returned to his native province, with the accumulated knowledge and experience derived from his connection with mining enterprises in that country. He has leased a silver mine at Tamchow, from which considerable ore had been taken, but the workings had been abandoned on account of water, which they could not get rid of with the appliances then used. To overcome the obstacle hitherto insuperable to mining as conducted by Chinese, he has provided mining machinery of the most modern and improved character. But his efforts to secure from the Chinese government the adoption of a more liberal policy in connection with mining operations are worthy of more attention. From a speech delivered by him at the opening of the Tai Yu Shan silver lead mine, a few miles from Hong Kong, we gather the following particulars, which are of importance in this connection. He has obtained from the provisional Government of Canton permission to work the mines. He endeavored to impress the Government with the important fact, that by opening up the mineral resources of the country, not only would profits accrue to those engaged in this business, but that great benefit would be derived from the employment of large numbers of the laboring classes, thereby furnishing remunerative employment to them at home, preventing emigration, and adding to the wealth of the country. He also urged the establishment by the Government of an office of mines, at which any person could obtain a license to open and work mines. This proposal has been favorably considered by the Viceroy, who has memorialized the Throne for imperial sanction. The Viceroy has already appointed two totais as superintendents of the mining office which was opened about March 1 last, and for about $1,025 any Chinaman could obtain a license to work any mine in perpetuity, the government receiving a royalty of the proceeds after all expenses are paid. This royalty the Viceroy and high officials have fixed at 10 per cent. for silver, that on other metals to be determined hereafter. More than 50 applications for licenses have been sent in since the office was opened, but before license is granted, the authorities will consult the residents in the vicinity of the proposed localities, to ascertain whether they object, for it seems admitted, that unless the operators have the support of the public, they cannot expect to succeed. I have deemed these facts of sufficient interest to report them, as they are indicative of progress, and justify the expectation that the day is not far distant when the mineral resources of this country will be developed, and a demand be created, not only for mining machinery of the most approved patterns, but also for the services of skilled mining engineers and other operatives, whose services must, for a time at least, prove indispensable. I will add that I have submitted this statement mainly because the Tai Yu Shan mine is located on the island of Lantao, only six or seven miles from Hong Kong, and that I had opportunity of judging by ocular inspection of the rich character of the galena exposed in the preliminary blastings."

The First Railroad in France.

(From the *Revue Scientifique*.)

MR. LEON AUCOC recalls the fact that in celebrating in 1887 the semi centennial of the inauguration of railroads in France a serious historical error will be committed.

In short he shows, from official documents, that the concession (or charter) for the railroad from St. Etienne to the Loire dates from February 26, 1823; that of the railroad from St. Etienne to Lyons from June 7, 1826; that of the railroad from Andrezieux to Rouen from August 27, 1828; and that of the railroad from Epinac to the Canal of Burgundy from April 27, 1830. All these concessions were made in perpetuity by royal ordinance. There followed the concession for the railroad from Alais to Beaucaire, the first case of a temporary or limited concession, which was authorized by the law of June 29, 1833. The railroad from Paris to St. Germain le Pecq was the sixth charter, by a law of July 9, 1835.

From the point of view of actual construction the line from St. Etienne to the Loire was opened October 1, 1828; that from St. Etienne to Lyons, in part, October 1, 1830; from St. Etienne to Roanne, February 5, 1834, while the road from Paris to St. Germain was only opened August 26, 1837.

The first railroads, it is true, were exclusively intended for the transportation of freight, and the motive power was furnished by horses or by stationary engines. But the transportation of passengers on the St. Etienne-Lyons line was begun in July, 1832, and in 1836 the number of passengers carried over the road exceeded 170,000. Finally it was at the same date, July, 1832, that Marc Seguin, who had taken out, in February, 1828, a patent for a tubular boiler, used for the first time on the St. Etienne-Lyons lines, the motive power which completes the railroad and gives it its true character, the locomotive.

In short, to pretend to celebrate in 1887 the semi-centennial of French railroads, according to this writer, is not only to mis-represent or to be ignorant of history; it is to lower the flag of France before several other nations, when in fact she either surpassed or at least equalled them in the beginning of her railroad system.

Manufactures.

Special Tools for Railroad Repair Shops.

In June, 1884, the Committee on Shop Tools and Machinery said, in its report to the Master Mechanics' Association:

"The age of special tools and machinery has come to stay, and those who adhere to old-time notions of doing work, getting one machine to do many kinds of work, doing no kind economically or accurately, will certainly be left behind."

This statement was doubtless correct and to the point.

The consolidation of railroads makes duplication of parts necessary for proper and efficient maintenance of repairs to locomotives and rolling stock generally; this duplication of wearing parts makes special tools and machinery a necessity, and new devices are being continually placed on the market. All machine-tool builders have their specialties and aim at the production of tools, the use of which will cheapen and simplify the work for which it is designed. Portable tools and machinery which are light and easily handled, have proved invaluable for round-house and repair-shop work; these machines can be taken to the work, and only those parts requiring repairs need be removed. This facilitates the work very much, and at the same time gives the use of the expensive stationary machine hitherto used, for other kinds of work.

Fig. 1

The first machine described in this article, and one of the earliest machines introduced in this particular line, is a Patent Portable Locomotive Cylinder Boring Machine, designed and used for boring out locomotive cylinders in their places by the removal of one or both heads and piston; the back-head, crosshead and guides need not be removed unless so desired. On removing the piston and leaving the front-head and stuffing-box, a small cone takes the place of the stuffing-box at once, and with proper adjustment at the front-head the machine is ready for work. It is fed with a constant feed of cut gears. The clamps or crossheads are so arranged that they may be conveniently used on locomotive cylinders of all sizes. The same bolts or studs that fasten the cylinder head on are used to bolt the bar-supports also. Two rods are fastened to the ends of the crosshead that supports the bar in the cylinder and to an adjustable swivel crosshead on the end of screw; these take the whole of the thrust and torsion strain of the bar. It makes no difference what position the bar is in, the end thrust is always in exact line with it, causing it to cut steady, smooth and absolutely true. The feed-nut is in halves, held together by a round nut, so that when the cut is through the cylinder, by unscrewing the round nut, opening the half-nuts, loosening the tools so that they will not mark the cylinder in moving back and pushing in the end of bar until the cutter-head is in its place, it is ready for work. The feed can be thrown out of gear at any time by simply screwing up the round-milled nut, and by loosening the nut the machine will feed automatically. The larger sizes of this machine are made with convenient change of feed so that after the roughing or truing cut has been taken, it can be instantly changed to a coarse feed, finishing quickly and accurately. An attachment is made with the driving power for holding it in position, rigid and firm, one end being fastened at the extreme end of the driving power, the other at the crosshead. By placing the crosshead vertically the driving power can stand horizontally, the bar is accurately ground, bearings scraped out to fit and it will stand a great amount of wear before loss of motion occurs. Cutter-heads are furnished for boring driving-boxes. These machines are built any size required and can be run by hand or power as desired. Fig. 1, shows machine with crank for turning by hand; fig. 2, shows a machine in actual operation, power being furnished by the "Gyp" engine.

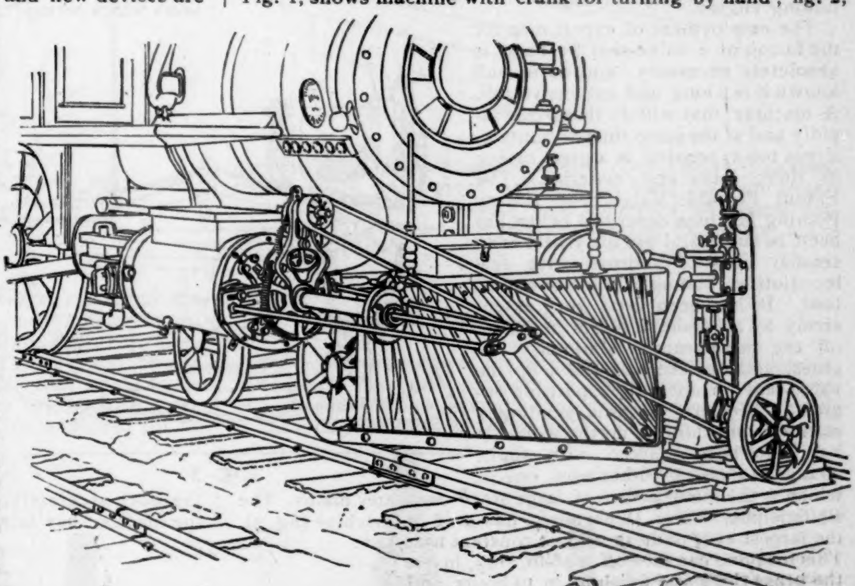


Fig. 2.

In addition to the machine described above we illustrate another Portable Cylinder Boring Machine differing in construction and operation and designed more particularly for re-boring all makes and sizes of steam-engine cylinders, pumps, steam hammers, blowing engines, air compressors, mining and hoisting engines, Corliss valves, hydraulic and steam-hoists, heavy housings, large wheels, etc., etc. In this machine the boring head travels, while in the former one, the bar travels. It is only necessary to take off the cylinder-head and remove the piston, when the cylinder can be rapidly and accurately bored out. This saves breaking the steam joints,

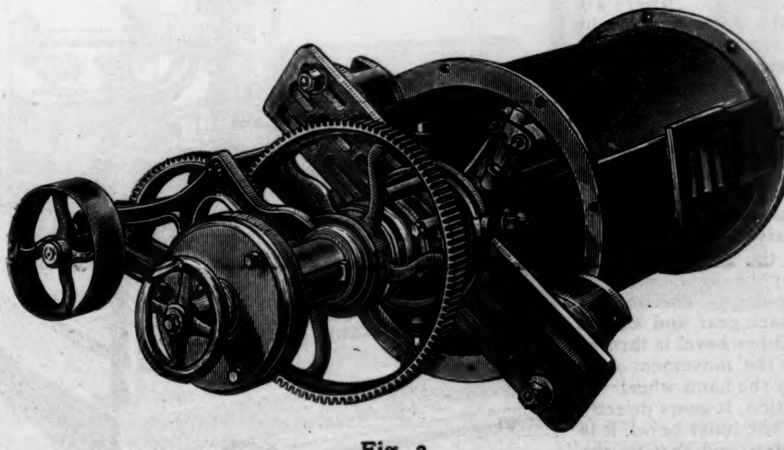


Fig. 3.

bolts, etc., and often the cylinder can be re-bored in less time than it would take to remove a cylinder from its bed. The cutter-heads are fed by a screw in one side of bar and operated by the feed-casing on the end which contains the gearing, by changing position of which two changes can be made and slow feed for roughing out and a fast for finishing cuts. The feed is automatic and at the pleasure of the operator. The bar is driven by a train of powerful cut gears, either with a crank or belt for power. With this machine there is furnished a self-centering chuck which fits in the stuffing-box, supporting the bar in a central position at the end. Fig. 3 gives a general view of this machine, while fig. 4 shows same re-boring in its present position on the engine-bed the cylinder of a mining engine.

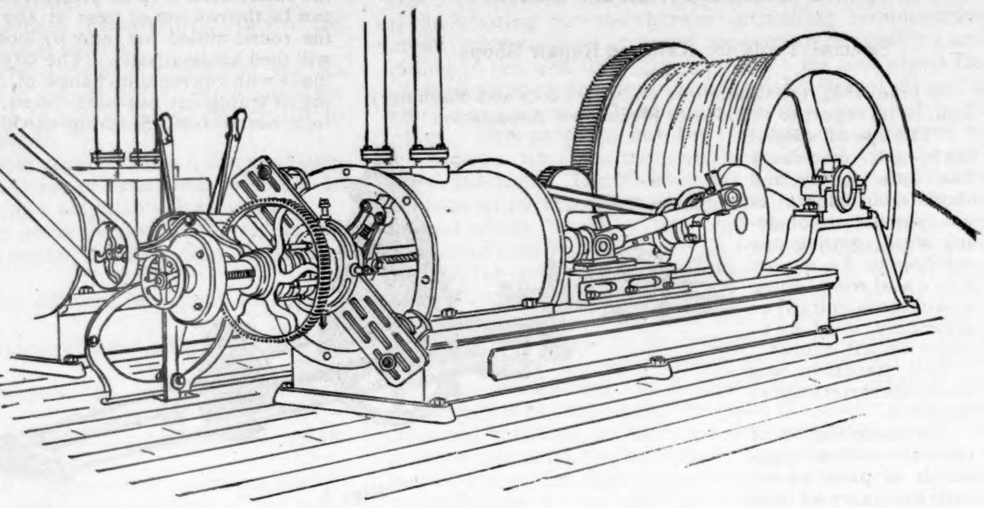


Fig. 4.

The employment of expert men for the facing of a valve-seat by hand is absolutely necessary, and as is well known it is a long and expensive job. A machine that will do this work rapidly and at the same time accurately, if not too expensive, is a great saving in time, labor and material. The Patent Portable Valve-Seat Rotary Planing Machine described below has been in successful use for years, even smaller lines of railroad with few locomotives finding it an economical tool. It has been used very extensively by its manufacturers in facing off the valve-seats of stationary engines, and they recently trued up the valve-seat on an upright plowing engine in Western Virginia, sending a man with machine to do the work. It has also been adapted with slight changes to various other uses, one of which is the manufacture of large stops for water mains. The Philadelphia Water Department has a 48-in. machine (fig. 5), the largest ever built, in almost constant use. This machine can face off a 48-in. stop, insert the brass rings and finish up in 10 hours, and when the machine is not in use, it is swung out of the way and the room utilized for other work. The construction, mode of attachment and operation of the machine, for general purposes (fig. 6.), is easily understood after an examination of the cut. There are two horizontal disks, the upper secured by radial arms, adjusted to suit the position of the studs in the valve-seat; the lower, carrying the cutter and its slide, revolves freely against the upper, and is held in place by a king-bolt passing through its center. This lower plate is also secured by a circular gib upon its circumference, which admits of taking up the wear. It is an annular gear, having teeth cut on its inner periphery, from which it receives its rotary motion by means of its connections with the bevel gears and crank. The crank may be replaced by a pulley if power be convenient. The double-bevel shaft acts like a back gear and admits of a change of speed. Either bevel is thrown into gear at pleasure by the movement of a pin in a slot operated by the hand-wheel. If the outer bevel is in action, it gears directly into the lower plate; if the inner bevel, it is slow geared to the outer, and that to the plate. The revolving lower plate is fitted with the V slide and the tool-post, and is fed by a screw and star wheel, arranged to give a large variation in the feed, from roughing to finishing, etc. The cutter is conveniently fed down by the operation of a nut on the cutter-spindle acting against the tool-post. The radial arms which secure this machine to the studs are so finished with slots as to give a wide range of adjustment.

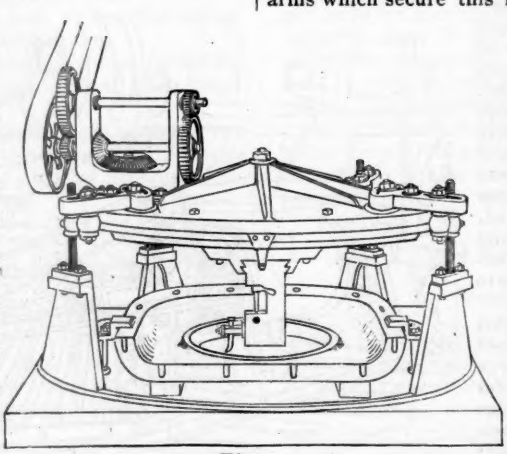


Fig. 5.

Great care has been taken to have the nuts and washers, that are furnished on the studs for holding the machine, clamp the radial arms so as not to spring the machines. The nuts are turned convex, and the washers are bored out concave, so that a perfect ball-and-socket joint is formed, allowing adjustment of the machine and holding it firm and solid, even though the stud should be out of line. In case the stud holes in a small seat should come inside the plates, four other radial arms are furnished with the machine, fitted with a T-slot, and with a hole at the other end corresponding to the hole for the old stud, thus affording facilities for extreme cases.

This machine, it is claimed, will do the work accurately, without the use of files or scrapers after the machine has faced off the seat. The plates are set true

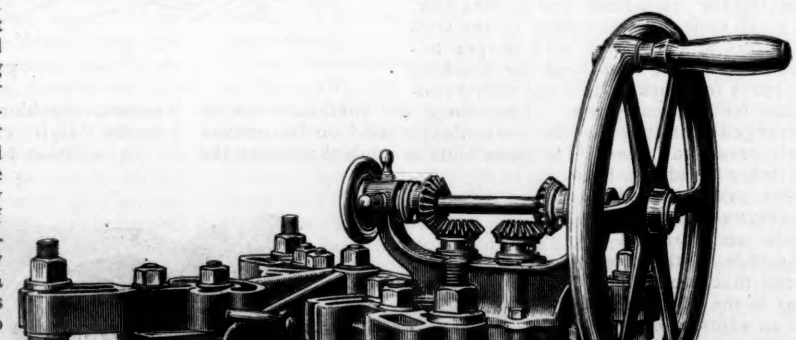


Fig. 6.

with the unworn parts of the valve-seat, consequently the new face will be likewise true. It is readily seen that the work done is exactly in line with the travel of the valve-stem, thereby preventing the yoke from slipping up and down the valve, as well as all extra friction on the valve-stem. No more material need be removed than is absolutely necessary to true up, thus saving the seat. The work is done by a con-

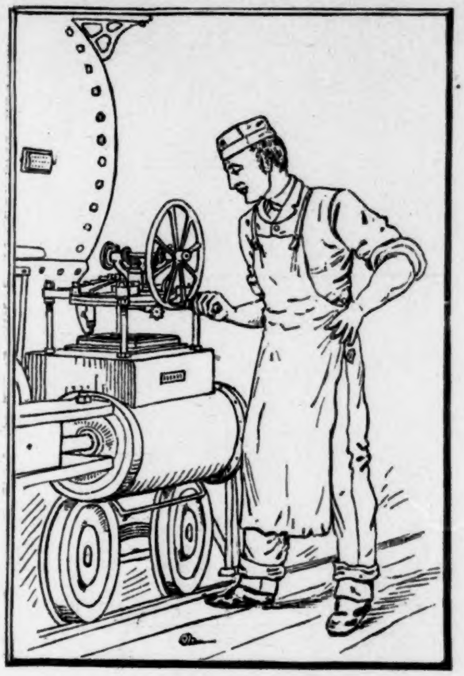


Fig. 7.

tinuous cut, and the loss of time from the return motion of the ordinary planer avoided. There is also no breaking out of the edges. It is estimated that an ordinary locomotive valve-seat can be trued up in two hours. These machines are strong and well fitted up, are easily handled and ought to be an excellent tool in every respect. They are built in three sizes, 18, 22 and 26 in. The 22-in. style is sufficient for all but the very largest class of locomotives. All the wearing surfaces are carefully scraped by hand, and the machines are thoroughly tested before being shipped from the works.

Fig. 7 shows this machine in operation by hand.

The Patent Portable Valve Chuck is used only in combination with the portable valve-seat rotary planing machine and is built in three sizes to suit the same. For round-house and repair-shop work, it is valuable, as the use of the planer is obviated entirely. The lower plate has dove-tailed slides that carry two movable jaws, operated by a right and left-hand screw, bringing them up central, firmly clamping the back of the valve and holding it central for planing. The four uprights at the corners have about 2 in. of adjustment, with graduations, enabling the machine to be set parallel with the table. After the seat has been faced, the machine is taken off and placed on the four graduated uprights of the chuck, the workmen then proceeding to face the valve. Fig. 8 shows the machine proper, and fig. 9 shows the machines in combination.

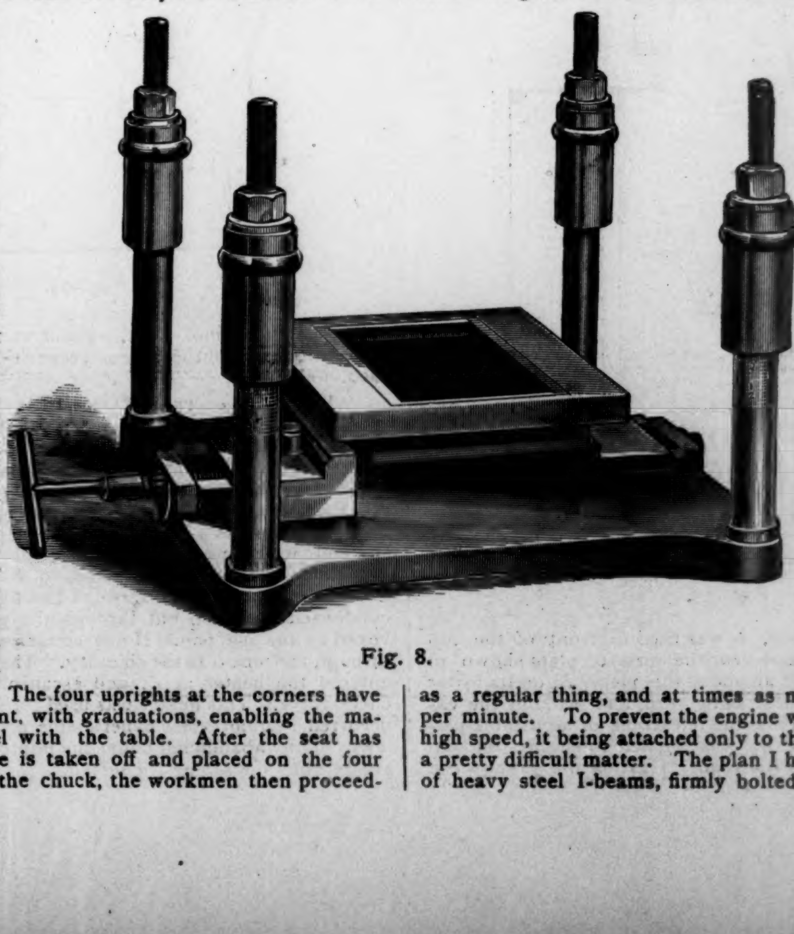


Fig. 8.

The tools illustrated in this article are made at the L. B. Flanders Machine Works of Messrs. Pedrick & Ayer in Philadelphia.

Vulcabeston.

The H. W. Johns Manufacturing Company, of New York, has brought out this new material, composed of asbestos combined with water and acid-proof materials, vulcanized and compressed. It is used for piston, piston-rod, ring-flange and

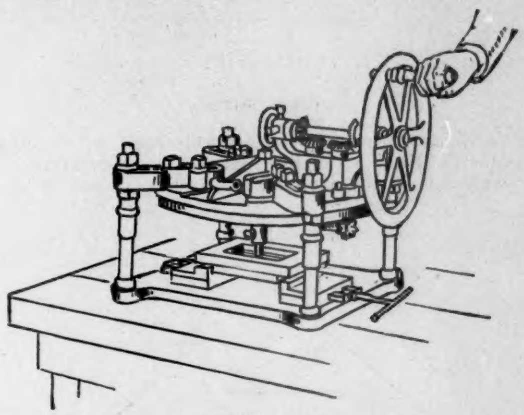


Fig. 9.

sheet packing, gaskets, washers, etc. One kind of vulcabeston is made water-proof and another kind fire and water-proof. The first is used for acid chambers for electric batteries, and the second is a non-conductor of electricity, but is not acid-proof.

Pumping Engines for the Potomac Flats.

At the last meeting of the Engineers' Club of Philadelphia, Mr. A. P. Broomell presented a description of the large engines which are to drive the centrifugal pumps in the works for draining the Potomac Flats at Washington. This description is given in the proceedings of the Clnb as follows:

"These engines have 24 × 24-in. cylinder. They are exceptionally heavy and substantial, the bed-frames alone weighing close to five tons. They will have automatic cut-offs, using my patent valves and governor. So far as I am aware, this is the first instance of using automatic cut-off governors of the single-valve type on connected engines. Since the shafts, and runners of pumps wear out very rapidly, it is necessary to make all parts of the governor in halves so that they may be readily taken off for renewal of shafts. The requirements of this work are very severe on engine, the speed being 160 revolutions as a regular thing, and at times as much as 200 revolutions per minute. To prevent the engine working endwise at this high speed, it being attached only to the floor of dredgers, is a pretty difficult matter. The plan I have adopted is a caging of heavy steel I-beams, firmly bolted and riveted together.

We are making two pairs of these engines, as well as five smaller ones for these parties. A few of the leading sizes are:

"Crank-shaft of hammered steel, 13 ft. long, 11 in. diameter. Main-bearings, 17 in. long, babbitt lined. Crank-pins, 6 × 6 in., hammered steel. Piston rods, cast-steel, 3⅜ in. diametet. Piston-heads have self-packing rings of cast-iron. Steam-pipes, 6 in. diameter. These dredging machines are owned and operated by Messrs. Benson & McNee, of Washington."

THE ROGERS LOCOMOTIVE AND MACHINE WORKS.

(Continued from page 88.)

Chapter V.

SMOKE BOXES.

As early as 1859 some engines were built, at the Rogers Works for the New Jersey Railroad & Transportation Company, with a form of extended smoke-box, shown in figs. 93

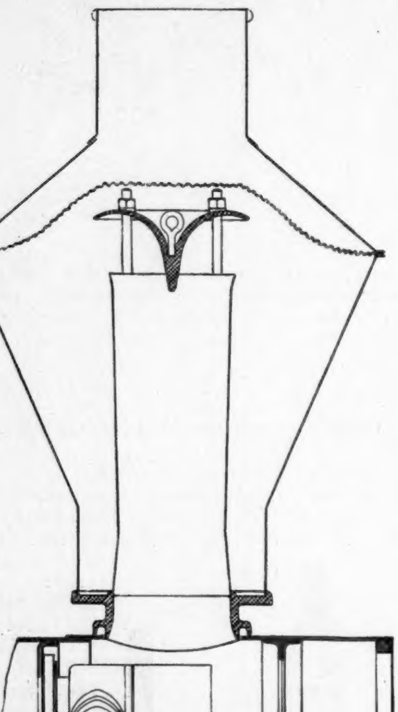


Fig. 93.

and 94. A deflecting plate, *A*, was used in front of the top rows of tubes. In the same year the form of plate shown in figs. 95 and 96, which had an adjustable piece, *B*, on its lower edge, was used on engines, both with and without the extended smoke-box. In 1862, the telescopic or adjustable petticoat pipe, shown in fig. 97, was applied to engines for the Nashville & Chattanooga Railroad. Figs. 98 and 99 show the extended smoke-box as recently applied to passenger engines. *A B* is a deflecting plate in front of the tubes, and *C C C* is wire netting of number 13 wire, and 2½ meshes to an inch. The exhaust nozzles *F F*, it will be seen, are carried up above the horizontal center-line of the boiler. A receptacle, *D*, for sparks, is attached to the under side of the smoke-box, and has a sliding door, *E*, for emptying the sparks and cinders which accumulate in the front end.

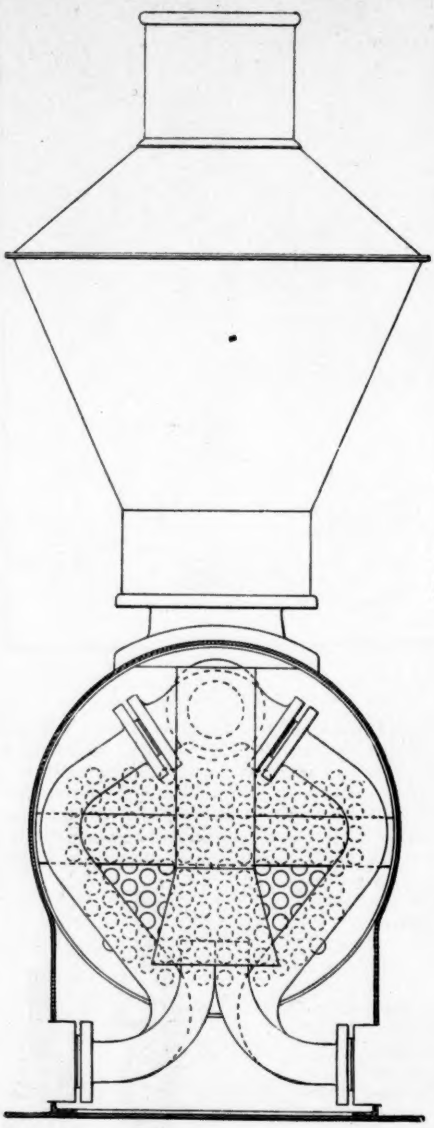


Fig. 94.

The extended smoke-box, when it was first introduced, met with little favor, but in recent years it has been extensively used.

FEED-WATER HEATER.

In 1859, Mr. Hudson designed a feed-water heater, which is represented by fig. 100, which he applied to a number of engines for the Southern Railroad of Chili, S. A. It consisted of a cylinder, *C*, filled with small tubes *F*. At the end of the cylinder there was a chamber *A*, and another, *B*, at the opposite end, which was connected together by the small tubes. The exhaust steam were admitted to *A* from the exhaust pipes by a pipe *D*, and passed through the small tubes to *B*. The condensed water ran out through the pipe *L*, or it was conveyed to the ash pan. If not condensed, the steam passed through the pipe *G* to the chimney. The water from the pump entered the heater at *E*, and escaped by the pipe *F*, to the check valve. This heater was used for some time, but, as has occurred in numberless experiments with feed-water heaters, it was finally abandoned under the impression that its cost was greater than the saving it effected.

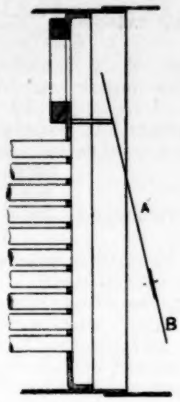


Fig. 95.

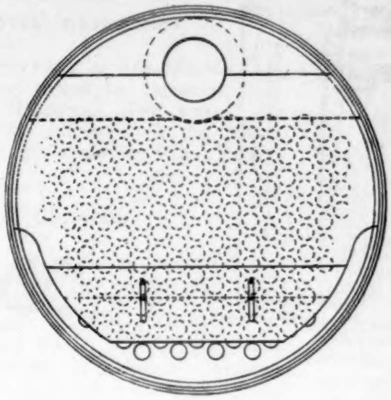


Fig. 96.

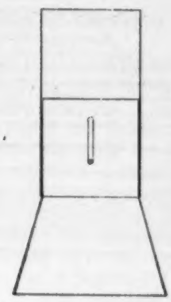


Fig. 97.

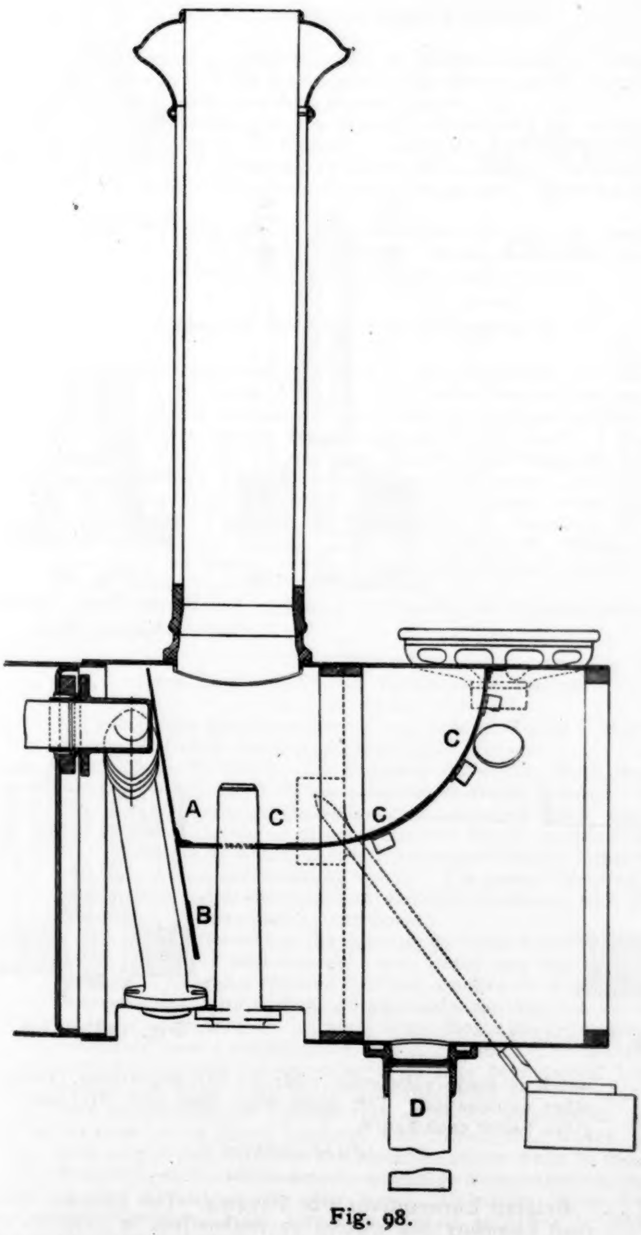


Fig. 98.

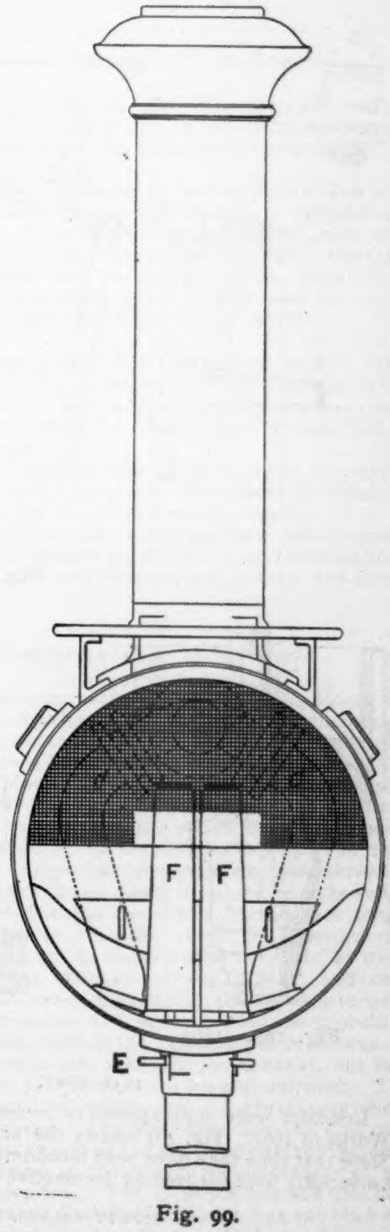


Fig. 99.

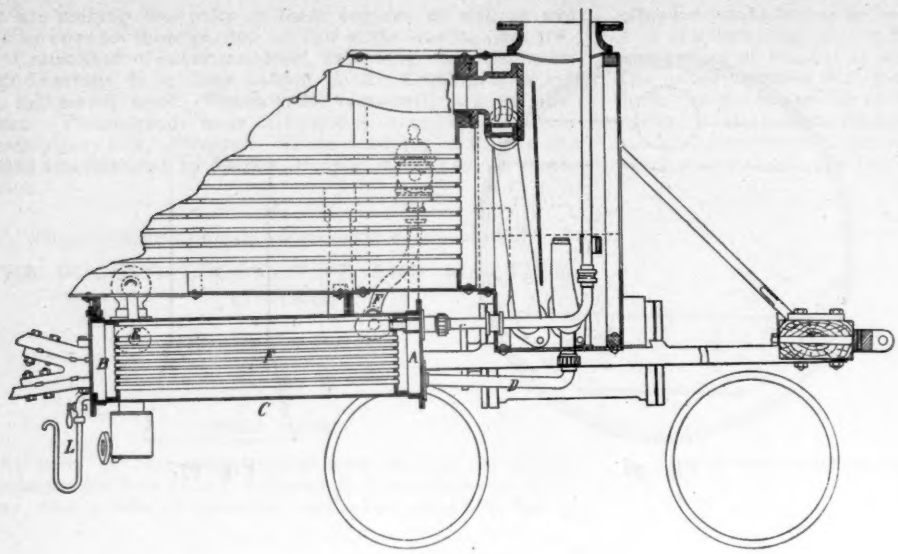


Fig. 100.

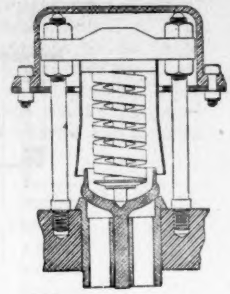


Fig. 104.—1872.

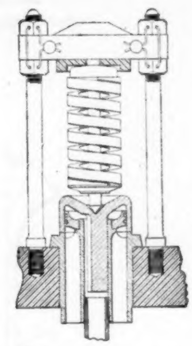


Fig. 105.—1875.

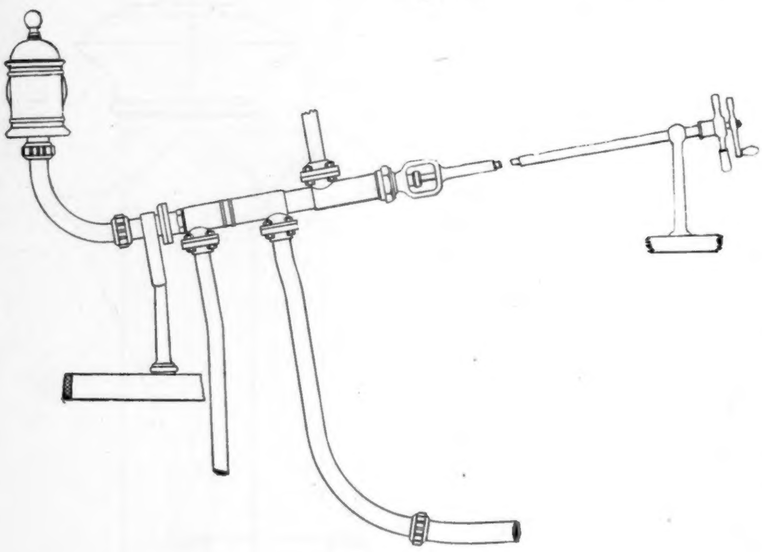


Fig. 101.

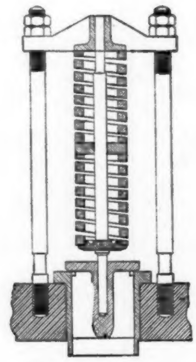


Fig. 106.—1882.

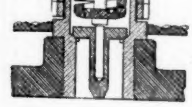


Fig. 107.
Steam Chest Safety Valve,—1882.

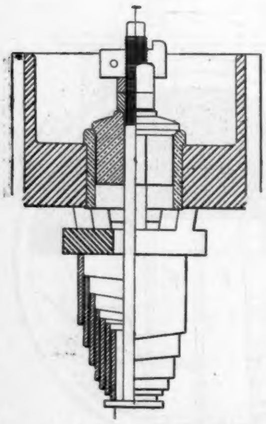


Fig. 102.—1869.

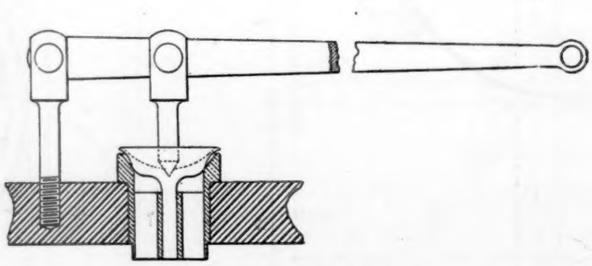


Fig. 103.—1872.

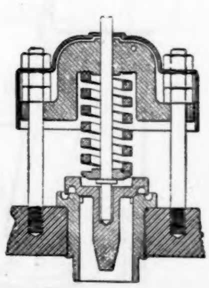


Fig. 108. —1883

INJECTORS.

Injectors were first applied to locomotives at the Rogers Works in 1861. Fig. 101 shows the arrangement then used. Since that time they have been much improved and are almost universally used for feeding locomotive boilers.

SAFETY-VALVES.

Figs. 102 to 108 represent different kinds of safety valves which have been used at various times, the construction of which is made sufficiently clear by the engravings, without other explanation. The dates when they were first used is given below each figure.

(*To be continued.*)

Belgian Locomotives For Panama.—The Panama Railroad Company has ordered 30 locomotives in Belgium, 18 from the St. Leonard Company and 12 from the John Cockerill Company at Seraing.

Proceedings of Societies.

Master Car-Builders' Association.

THE office of M. N. Forney, Secretary of the Master Car-Builders' Association, will, on May 1 next, be removed from No. 23 Murray street to No. 45 Broadway, New York. All business letters and communications intended for the Secretary should be addressed to him at 45 Broadway from May 1, accordingly.

Engineers' Club of Cleveland.

THE annual meeting of this Club was held in Cleveland, O., March 8. Reports were received from the officers and committees, and the following officers were elected for the ensuing year: President, John Whitelaw; Vice-President, W. R. Warner; Corresponding Secretary, C. O. Arey; Recording Secretary, C. M. Barber; Treasurer, S. J. Baker; Member of the Board of Managers of the Association of Engineering Societies, M. E. Rawson.

The Committee on National Public Works reported that a meeting of civil engineers would be called during the summer at Washington, to take measures to influence legislatio in the next Congress.

Boston Society of Civil Engineers.

THE annual meeting was held in Boston, March 16, President George L. Vose in the chair. The officers and Governing Committee presented their annual reports.

After the reading of the reports, officers for the ensuing year were elected as follows: President, L. F. Rice; Vice-President, F. P. Stearns; Secretary, H. L. Eaton; Treasurer, Henry Manley; Auditor, Thomas Aspinwall; Librarian, H. D. Woods.

After the adjournment of the business meeting, the annual dinner of the Society was given at Young's Hotel, a large number of members and invited guests being present.

Canadian Society of Civil Engineers.

THE organization of this Society was completed at a meeting held in Montreal, Feb. 24. The same evening the members attended a reception given in honor of the new society.

The officers chosen are: President, T. C. Keefer; First Vice-President, Walter Shanley; Second Vice-President, Col. C. S. Gzowski; Third Vice-President, J. Kennedy; Secretary and Treasurer, Prof. Henry J. Bovey; Council, Alan Macdougall, H. F. Perley, F. N. Gisborne, H. D. Lumsden, H. S. Poole, P. W. St. George, E. P. Hannaford, H. Wallis, S. Keefer, Hurd Peters, H. N. Ruttan, W. T. Jennings, H. T. Bovey, Louis Lesage, P. A. Peterson.

The headquarters and place of meeting of the new society will be in Montreal.

New England Water Works Association.

THE regular monthly meeting was held at Young's Hotel, Boston, March 9, about 50 persons being present.

Mr. Albert F. Noyes, City Engineer of Newton, Mass., read a paper on Driven Wells as a Source of Water Supply. He began with a historical sketch in which he named when, where and by whom the use of driven wells was begun in this country. Colonel Green and Calvin Horton are closely identified with this method of obtaining water. The paper described in considerable detail the tools and methods employed, and distinguished between driving and boring.

The great difference in the quantity of water which is stored in the voids of different soils was noted and figures were quoted. The writer insisted that the amount of water to be obtained from any system of pipe-wells can only be known with any approach to certainty after thorough experiments extending over a considerable period of time. The question as to the comparative amounts of water to be obtained from driven and open wells was briefly discussed and the conclusion reached that no general rule could be formulated. By the courtesy of Chief Engineer Van Buren, Mr. Noyes was able to give full details of the Andrews driven wells in use at Brooklyn, N. Y., which may be quoted as a successful example of this method of obtaining water. Cohassett, Hyde Park and Westboro, Mass., were mentioned as towns in which driven wells have been successfully used.

The paper was discussed at length by Messrs. M. M. Field, J. A. Tilden, C. F. Allen and President Rogers. Opinions were expressed that where driven wells were used it was necessary to have careful inspection to determine the quality of the water before using it; also, that no more water can be obtained by any patented process than can be had by any simple method of driving.

Engineers' Society of Western Pennsylvania

A REGULAR meeting of this Society was held in Pittsburgh, March 15. Resolutions of regret at the death of Captain James B. Eads were unanimously adopted.

Mr. Thatcher read a paper on Bridge Specifications, with especial reference to those adopted by the Keystone Bridge Company. This paper called out a long discussion.

Colonel J. P. Roberts then read a paper on the High and Low Water Lines as fixed at Pittsburgh, pointing out the difficulty of determining either. He proposed the adoption of a system for the determination of these lines up the Monongahela to McKeesport, up the Allegheny to Hulton and down the Ohio to Sewickley. It was decided to appoint a committee of seven to lay the matter before Col. W. E. Merrill, of the United States Engineers, the city authorities, the Chamber of Commerce and the Coal Exchange, to report back any modifications or improvements which it may deem advisable.

The Society has secured permanent quarters in the Penn Building in Pittsburgh, and its meetings will be held there hereafter.

American Society of Civil Engineers.

AT the meeting of March 2 Mr. Wm. Metcalf read a paper on Steel: Its Properties; its Use in Structures and in Heavy Guns. An abstract of this paper will be found on another page

This paper was discussed by Major Miller, Captain F. V. Green, Commander Robson, Lieutenants Danenhower and Rogers, Mr. R. W. Hunt and others. Letters were also read from Senator Miller and Lieutenant Ingersoll. Owing to the length of the paper and the lateness of the hour, the discussion was necessarily brief, and it was decided to take up the subject again at the regular meeting in April.

At the meeting of March 16 a paper was read by Mr. C. W. Tompkins, on the Brick Industry in New York and its Vicinity. This paper gave an interesting account of the manufacture of bricks at various points near New York. It was followed by a short discussion

Mr. A. M. Wellington then gave a short account of the Bussey bridge on the Boston & Providence Railroad, the fall of which caused the recent very fatal accident.

Mr. Henry S. Pritchard, of Philadelphia, was introduced by Mr. Wellington and gave an account of his investigation of the fallen bridge. He also showed two broken eye-bars taken from the bridge.

Engineers' Club of St. Louis.

A REGULAR meeting was held in St. Louis, March 2, President Potter in the chair; 24 members and 3 visitors present.

Messrs. Alexander E. Abend, Charles F. Muller, Max G. Schinke and Lewis Stockett were elected members.

Mr. Robert Moore then read a paper on the Present Aspects of the Problem of Inter-Oceanic Ship Transfer. A history of the various schemes which had been made public was given, as well as the results reached and the difficulties yet to be met. At present the question had narrowed down to three prominent routes, each of which had its supporters. The De Lesseps Panama Canal was discussed at length, the present condition of the work noted, its cost thus far, and the amount necessary to finish it shown. This, as well as the grave engineering difficulties to be solved, and on which the success of the work hinged, led the speaker to believe its completion impossible and its early collapse probable. The second scheme, known as the Tehuantepec route was, for topographical reasons, not available for a canal, but has been chosen by Capt. Jas. B. Eads for his ship railroad. This plan was also discussed at length, and its advantages and disadvantages considered. The great first cost, the cost of operating, and the serious and as yet unsolved engineering difficulties to be met, seemed to throw the preponderance of evidence against the enterprise. The third scheme was that known as the Lake Nicaragua Canal which, so far, has not been as prominently mentioned as the others. While its first cost is un-

doubtedly great, it is not so large as either of the others, and its operating expenses would be much less. The work was of great magnitude, but yet of a character which had already rn many instances been successfully handled, and in the whole toute nothing new or untried would be met. On the whole, he speaker believed the Nicaraguan scheme the one which best deserved the recognition and support of the American people.

The paper was discussed by Messrs. Potter, Seddon, McMath, H. C. Moore and Ockerson.

A REGULAR meeting was held in St. Louis, March 16; 26 members and 2 visitors present. Mr. George W. Dudley was elected a member.

The President made the formal announcement of the death of Capt. Jas. B. Eads, suggesting appropriate action by the Club.

On motion the President was directed to appoint a committee of three to draw up suitable resolutions. Messrs. McMath, Moore and Holman were appointed such committee. On vote it was decided that the Club attend the funeral in a body.

The President announced the receipt from the Mississippi River Commission of a map of the alluvial basin of the Mississippi River from the St. Francis basin, south.

Mr. Carl Gayler then read a paper on Anchorage of Suspension Bridges, describing the common practice, and making some criticisms; also suggesting certain improvements, as adopted in the city's practice. The paper was discussed by Messrs. Johnson, Frith, Holden, Seldon, Macklind and Moore.

The Club then adjourned.

American Society of Mechanical Engineers.

THE following circular has been issued by the Secretary, Mr. F. R. Hutton:

"By a resolution of the council, pursuant to the request and suggestion of a large number of the members, the XVth Meeting of the Society will be held in the City of Washington, D. C., about the middle of May, 1887. The exact date and further details will be the subject of later announcements.

"Papers for this Meeting must be in the Secretary's hands before March 25, and titles should be sent on at once. It may be mentioned that fewer papers than usual have been so far contributed and promised, and the obligation is urged upon every member to see that our *Transactions* are not allowed to deteriorate in value from his inaction. Topics are also solicited for the topical discussions at once. The Secretary will be glad to correspond immediately with members who have subjects to present."

Master Mechanics' Association.

MR. J. H. SETCHEL, Secretary, has issued the following circulars from his office at Dunkirk, N. Y.:

PROPORTIONS OF LOCOMOTIVE CYLINDERS.

1. What rule do you recommend being used in calculating proper size of cylinders of passenger locomotives, when boiler steam-pressure, diameter of driving-wheels and weight on same are given quantities?
2. State what, if any, deviation from this rule should be made in the case of freight and switching engines.
3. State your reasons for adopting such rules, and, if possible, demonstrate the correctness of the same by results obtained in every-day practice.
4. In making the calculations referred to, do you assume the diameter of driving-wheels to be diameter outside the tires when new, or when half worn? What percentage of boiler pressure do you assume to be the average cylinder pressure?
5. Does your experience indicate that engines in which the ratio of weight on drivers to tractive power is much below the average, give better or worse results in work done, and in the economical performance of same, than engines of same tractive power, and in which the ratio between weight on drivers and tractive power is above the average? Is life of tires longer in one case than the other?
6. If you can present any facts bearing on this subject and which may be of service to the Association, you are respectfully requested to communicate the same.

F. L. WANKLYN,
T. E. BARNETT,
CHARLES BLACKWELL,
Committee.

Replies should be addressed to Mr. Charles Blackwell, care Union Pacific Railway, Omaha, Nebraska.

ARRANGEMENTS FOR ANNUAL MEETING.

Arrangements have been made with the proprietors of the Hotel Ryan, St. Paul, for the accommodation of members of the Association and their friends who will attend the 20th annual convention, to be held at St. Paul, commencing Tuesday, June 21, 1887.

The charge will be $2.50 per day for each person. Additional charges for extra accommodations.

Members requiring rooms are requested to engage them if possible before June 1, by filling up the enclosed blank and mailing it to the Hotel Ryan, St. Paul, Minn. Any members who, after having secured rooms as above, find themselves unable to attend, will confer a favor by notifying the proprietors of the Hotel Ryan at as early a date as possible.

G. W. CUSHING,
CLEM HACKNEY,
R. W. BUSHNELL,
Committee.

Engineers' Club of Minneapolis.

AT the last meeting of this Club in Minneapolis, Feb. 21, a letter from G. W. Wilder, of New York, on Coast Defenses, was read:

The subject of Heating Railroad Cars by Steam was discussed, the universal opinion being that it was time to take some action relative to heating cars that would insure safety as well as comfort.

The Club appointed the following standing committees for the ensuing year:

Library and Literature—W. W. Redfield.

Bridges and Material—F. W. Coppdin, A. J. Riggs and William R. Hoag.

Railroads and Transportation—J. W. Kendrick, E. T. Abbott and M. D. Rhawn.

Sewers and Drainage—F. W. Carr and C. W. Redfield.

Engineering Jurisprudence—John Lamb.

Building Material and Sanitation—Fred. Keyes, J. M. Hogan and G. Sidney Houston.

Rivers and Canals—D. P. Waters, G. W. Sturtevant and F. H. Todd.

Streets and Paving—George W. Cooley and C. E. Sprague.

Surveying and Topography—F. L. Shaw, A. C. Libby and Frank Plummer.

Weights and Measures—W. S. Pardee, Robert Augst and Edward Barrington.

Machinery—R. H. Sandford, J. H. Barr and William de la Barre.

Water Supply—J. Waters and D. P. Waters.

Municipal Engineering—Andrew Rinker, William de la Barre, E. T. Abbott and William Van Duzen.

Contracts and Management of Work—P. B. Winston.

Engineers' Club of Philadelphia.

A REGULAR meeting was held at the Club House in Philadelphia, Feb. 19, President T. M. Cleemann in the chair; 34 members and 1 visitor present.

Mr. John Fernie, C. E., Member Institute of Civil Engineers, Institute of Mechanical Engineers, etc., of England, delivered an entertaining and instructive address upon the Mechanical Genius and Works of the late Sir Joseph Whitworth.

A REGULAR meeting was held at the Club House in Philadelphia, March 5, President T. M. Cleemann in the chair; 15 members and 1 visitor present.

Mr. S. L. Kneass presented an illustrated description of a new Fixed Nozzle Automatic Injector which will restart itself, if from any cause its supply of water or steam be temporarily interrupted. It is especially designed for locomotive service, where its power of adapting itself to varying steam pressures and its automatic action are especially desirable. He closed with a few remarks on the theory of the action of the injector and its efficiency.

Mr. R. W. Lesley presented illustrated notes upon the manufacture of Cement in the United States and the Growing Demand for High-class Mortars. The Secretary presented, for Mr. Theodore J. Lewis, a paper upon 3-in. *vs.* 4-in. tires for locomotives.

The Secretary presented, for Mr. A. P. Broomell, an illustrated description of the Large Engines being built to drive

the Centrifugal Pumps for reclaiming the Potomac Flats, Washington, D. C.

The Secretary also presented, for Mr. Broomell, a copy of an Ice Machine, which he had designed with a view of overcoming some of the objectionable features in previous machines.

The Secretary presented sundry announcements as to current business and correspondence.

Western Railway Club.

THE regular monthly meeting was held in Chicago, March 16, President Scott in the chair. The regular subject, Car Heating, was taken up.

Mr. Forsythe opened the discussion in a long address, in which he expressed the opinion that all forms of stoves and heaters would, in the end, have to give way to some system of continuous heating. He believed that the increase in grate surface and boiler capacity of locomotives would enable them to meet the demand for steam for heating purposes. The great objection to continuous heating, in his mind, was the difficulty of heating cars when detached from the locomotive, and he believed that that could be met.

The Sewall, the Harrington, the Herr and the Cline systems of heating were then described at length by their inventors or representatives.

Letters were read from Mr. Johann describing the means he had taken to make heaters safe; from Mr. Lowry, describing the Martin system, and from Mr. Hickey, describing the difficulties encountered on far northern roads, subject to interruption by snow.

Mr. Gibbs described the experience had with the Martin heater on the Chicago, Milwaukee & St. Paul road, the results so far being favorable. He thought that further experiments would be needed to settle the question, as the trial this season had been short.

After some discussion the following resolution was passed:

"That it is the sense of the members of the Western Railway Club that it would be advisable for railway companies to investigate thoroughly and experiment with continuous steam heating of passenger trains; and that a committee of three be appointed to endeavor, through the managers or general superintendents of some of the prominent railroads running into Chicago, to equip trains on different roads with different devices."

It was explained that this resolution was intended to refer only to continuous heating methods, but not to discourage experiments by individuals or roads in any direction they pleased.

The rules of interchange were then taken up, beginning with Rule 21. On motion of Mr. Meade the following sentence was recommended to be added to Rule 21:

"If new standard parts mentioned in Rule 15 be more expensive than original construction, allowance shall be made for the same as may be agreed upon."

Rules 22 to 29 were passed without alteration.

Mr. Meade moved that in Rule 30 the words "or in process of purchase," be stricken out. Carried.

Mr. Rhodes submitted the statement of the committee appointed at the January meeting to report on the height of empty freight cars from the center of draw-bar to top of rail of all roads having representative members in the Association.

The subject for discussion at the April meeting will be the report of the Committee on Interchange Rules.

New England Railroad Club.

THE regular March meeting, which was also the fourth annual meeting, was held at the Club Rooms in the Boston & Albany station in Boston, on Wednesday evening, March 9. There was a very large attendance.

The Secretary and Treasurer, Mr. J. M. Ford, presented his annual report, showing that the cash on hand at the beginning of the year was $131; received from dues, $316; total, $447; expenditures, $296; leaving a balance of $151. The present membership is 176, a gain of 17 over the previous year. The average attendance at the monthly meetings has been 113.

The nominating committee appointed at the February meeting presented a list of officers, and the following were elected for the ensuing year: President, J. N. Lauder; Vice-President, George Richards; Secretary and Treasurer, F. M. Curtis; Executive Committee, J. N. Lauder, F. D. Adams, J. W. Marden, J. K. Taylor, J. M. Ford, A. M. Wait, Albert Griggs, J. T. Gordon; Finance Committee, James Smith, Charles W. Sherburne, A. G. Barber, Isaac N. Keith, Robert Johnson, Joel H. Hills, Daniel S. Page.

The routine business being completed, the subject for discussion—Lighting and Ventilating Cars in Passenger Service—was taken up.

A communication from Mr. J. M. Foster, describing his system of lighting by means of compressed gas, was read by the Secretary. A recess of 10 minutes was then taken to enable the gentlemen to personally inspect the Jullien system of lighting by electricity from storage batteries, as exhibited on car No. 90 of the Boston & Albany Railroad. This system is described elsewhere.

After the inspection, Mr. Fowler and Mr. Reed explained the system and its workings, answering questions which were asked in relation to it.

Ex-Gov. Howard, Superintendent of Tests at the Watertown Arsenal, explained the Pintsch system of lighting with gas, stating that 22,000 cars are thus lighted, mostly in Europe.

Mr. Thomas Wise then explained a system of ventilating by means of a fan-blower run from the car-axle, and a plan of electric lighting by means of a dynamo, also run from the car-axle.

President Lauder said he was glad so much valuable information had been given on the subject of lighting, and while he thought electric light was to be the future light, he said at the present time there are no data to show the actual cost, but it now looks as though it is far too heavy for most roads to put in operation.

On motion of Mr. Marden, it was voted to continue the same subject for discussion at the next meeting. The Club then adjourned.

Master Car-Builders' Club.

THE regular monthly meeting was held at the rooms, No. 113 Liberty street, New York, on the evening of March 17, Mr. C. E. Garey in the chair.

Mr. C. E. Garey was unanimously chosen Chairman of the Club (in place of the late Leander Garey) and returned thanks in a brief speech.

The subject—Car Heating, Lighting and Ventilation was then taken up.

Mr. Woodward explained the construction and operation of the Sewall system of heating trains by steam from the locomotive, and also gave some notes of the results obtained on the Maine Central road. He said that the company was fitting up two trains for the Fitchburg road, one for the Michigan Central and one for the New York & New England. The present cost is about $300 per car.

The Frost heater, which is so arranged that in case of any disturbance of equilibrium the fire drops into a tank full of water, was then shown, the inventor giving a practical demonstration by upsetting his heater, the result being a general wetting of feet and much sneezing as smoke and gas filled the room.

The Condon heater was then shown, the safety claimed in this case being due to careful construction, double doors, etc.

President Ladder, of the New England Club, being in the room, was called for and made a brief address, in which he urged the necessity of work to keep up the standard of the Club. Mr. Lauder also spoke at some length on the question of heating. He said that there was a demand for systems of continuous heating, and urged the importance of adopting some uniform system of coupling for the steam pipes on the cars. He further spoke of the uselessness of applying safety systems to the passenger cars and leaving an old cast-iron stove in the baggage car, where it was peculiarly subject to accident.

Mr. M. Hurley, of Quebec, then made an address in which he claimed to be the first inventor of a system of steam heating.

The Plass system of heating by gasoline was then explained. To this, the objection was urged that gasoline was extremely dangerous to store or carry in quantities.

The Pennock system of electric lighting was then explained. In this, a storage battery is used, the battery intended to supply 10 lights of 10-candle power weighing about 1,000 lbs., and needing recharging once a week. This system is to be tried on the Baltimore & Ohio, the Delaware & Hudson, the New York Central and the Manhattan Elevated lines.

Mr. Lauder spoke of the Jullien system of electric lighting, now on trial on the Boston & Albany road; in this, the battery weighs 1,800 lbs.

Owing to the lateness of the hour the discussion was closed, and the meeting adjourned.

At the April meeting the subject for discussion will be the same—Heating, Lighting and Ventilating Passenger Cars.

PERSONAL.

Mr. Cabell Breckenridge is Division Engineer of the new Tennessee Midland road.

Mr. C. C. Chandler has been appointed Chief Engineer of the Ohio & Mississippi road.

Captain John A. Kress has been promoted to be Major of Ordnance in place of Parker, promoted.

Mr. J. W. Robinette has been appointed Chief Engineer of the Elizabeth & Hodgensville Railroad.

Mr. James J. Todd has been appointed Assistant Roadmaster of the New London Northern Railroad.

Lieutenant F. P. Gilmore, U. S. N., has been ordered to duty as Inspector of steel for the new cruisers.

Mr. H. Pierce is appointed Engineer of Maintenance of Way of the Cincinnati, Hamilton and Dayton road.

Mr. Stacy B. Opdyke has resigned his position as Superintendent of the New Haven & Northampton Railroad.

Mr. C. S. Dwight, of Winnsboro, S. C., is Division Engineer on the New Georgia, Carolina & Northern road.

Lieutenant Charles L. Potter has been transferred to the Corps of Engineers in place of C. E. Gillette, promoted.

Mr. W. Bell Dawson has been appointed Assistant City Engineer of Toronto, Ont., by the Board of Public Works.

Mr. W. McLeod has been appointed General Roadmaster, with charge of the Kansas divisions of the Missouri Pacific.

Mr. E. Holbrook has resigned his position as Division Superintendent on the New York & New England Railroad.

Major Francis H. Parker has been promoted to be Lieutenant Colonel of Ordnance in place of Whittemore, promoted.

Mr. Lyman Anderson is Engineer in charge of the construction of new and extensive iron-pipe works at Birmingham, Ala.

Lieutenant Colonel James M. Whittemore has been promoted to be Colonel of Ordnance in place of McAllister, deceased.

Mr. W. B Ruggles, Chief Engineer of the Ohio & Mississippi Railway, has resigned that position, dating from March 1.

Mr. J. F. Morrison, of Athens, Ga., has been appointed Chief Engineer of the projected Georgia, Carolina & Northern Railroad.

Mr. James Harrington has been appointed Chief Engineer of the Cleveland, Akron & Columbus road, with office at Akron, Ohio.

Mr. L. O. Gassett has resigned his position as Master Mechanic of the Erie Division of the Lake Shore & Michigan Soulhern road.

Mr. John P. Ray, for some years General Foreman of the Union Pacific shops at Omaha, has resigned and will go into other business.

Mr. William Patterson has been appointed Master Car Builder of the Minnesota & Northwestern road, with office in St. Paul, Minn.

Mr. C. H. Blakesley has resigned his position as Master Mechanic and Assistant Superintendent of the Western Railroad of Florida.

Mr. L. F. Wakefield has been appointed Chief Engineer of the projected Sioux City & Northeastern road, with office at Sioux City, Iowa.

Mr. C. K. Lawrence has been appointed Engineer of Maintenance of Way of the St. Paul, Minneapolis & Manitoba road, with office in St. Paul.

Mr. C. J. Bechdolt has been appointed Assistant Engineer of the Middle Division of the Pennsylvania Railroad in place of C. K. Lawrence, resigned.

Mr. Edward Barrington has been appointed Chief Engineer of the Wichita, Cedarvale & Southeastern, a road in Kansas. His office is at Wichita.

Mr. D. Horrie has been appointed Superintendent of Bridges of the Milwaukee, Lake Shore & Western road, with headquarters at Kaukauna, Wis.

Mr. J. S. Graham has been appointed Master Mechanic of the Erie Division of the Lake Shore & Michigan Southern road in place of L. O. Gassett, resigned.

Mr. Alexander Abend has been appointed Division Engineer on the new Tennessee Midland road, and will be located for the present at Knoxville, Tenn. He has been for some time Engineer of the Belleville (Ill.) Water Works.

Mr. Emil Swensson, formerly Assistant Engineer of the South Pennsylvania Railroad, is now in the office of the Phœnix Bridge Company at Phœnixville, Pa.

Mr. T. Hartman has resigned his position as Assistant to the President of the Memphis & Little Rock road, and will go into business as a railroad contractor.

Mr. John Duffy has been appointed Master Mechanic of the Toledo, Columbus & Southern Railroad, with office at Toledo, O., succeeding Mr. H. S. Herrick.

Mr. Marriott C. Smyth has resigned his position as Secretary and Treasurer of the Midvale Steel Works in Philadelphia after 20 years' service with the company.

Mr. J. H. Burnett has been appointed Master Mechanic of the Jacksonville, Tampa & Key West Road. He was recently on the Louisville & Nashville road.

Mr. J. S. Ward has been appointed Engineer of the North Penn & Bound Brook Division of the Philadelphia & Reading Railroad in place of Mr. E. Chamberlain, resigned.

Mr. E. J. Roberts has been appointed Chief Engineer in charge of the St. Paul, Minneapolis & Manitoba Extension into Montana, which is to be built during the present year.

Mr. H. Spidel, of Rock Island, Ill., has been appointed Chief Engineer of the Memphis, Trinidad & Pueblo, a projected road, and will have his headquarters at Greensburg, Kansas.

Mayor Smith, of St. Paul, Minn., has appointed the following to be members of the New Board of Public Works: John C. Quimby, Richard L. Gorman, William Barrett and Edward C. Starkey.

Mr. Samuel Oakley has been appointed General Car Foreman of the St. Paul, Minneapolis & Manitoba road, with office at St. Paul, Minn. He was recently on the Canadian Pacific road.

Mr. Charles O. Haines has been appointed Superintendent of the new Savannah & Tybee Railroad. He is a son of Mr. H. S Haines, General Manager of the Savannah, Florida & Western road.

Col. George E. Waring has been appointed Consulting Engineer to the city of San Diego, Cal. His plans for the sewer system of the city have been adopted with some slight modifications as to the outlet.

Mr. S. M. Rowe has been appointed Resident Engineer of the Atlantic & Pacific Railroad, with headquarters of Albuquerque, N. M. He will have charge of maintenance of way, bridges, buildings and water service.

Mr. E. J. Blake has been appointed Chief Engineer of the Hannibal & St. Joseph and the Kansas City, St. Joseph & Council Bluffs railroads in place of Mr. C. C. Chandler, who goes to the Ohio & Mississippi road.

Mr. Charles Howard has been appointed Superintendent of the Providence & Worcester Railroad, in place of W. E. Chamberlain, resigned. Mr. Howard was recently on the Worcester Division of the Fitchburg road.

Mr. William E. Chamberlain has resigned his position as Superintendent of the Providence & Worcester Railroad. He has been on that road for some 10 years, and was previously Master Car-Builder of the Boston & Albany.

Mr. Axel S. Vogt has been appointed Mechanical Engineer of the Pennsylvania Railroad in place of Mr. John W. Cloud, who has gone to the New York, Lake Erie & Western road. Mr. Vogt has been with the company for some time.

Mr. George H. Watrous has resigned his position as President of the New York, New Haven & Hartford Railroad Company. He has held the office since 1879, and was previously Counsel of the company. He retires on account of ill health.

Mr. James C. Bayles has been appointed President of the New York Board of Health by Mayor Hewitt in place of Gen. Shaler, removed. Mr. Bayles is Editor of the *Iron Age*, and is well known as a writer of ability on sanitary and construction topics.

Mr. John Robinson has been appointed Master Mechanic of the Buffalo Division of the Lake Shore & Michigan Southern road in place of J. S. Graham, transferred to the Erie Division. Mr. Robinson has been for some time Foreman of the Enginecouse at Elkhart.

Mr. John E. Fry, formerly Manager of the Bessemer Steel Department of the Cambria Iron Company, and recently Superintendent of the St. Louis Ore & Steel Company, has been appointed Manager of the Wheeling Steel Works at Benwood, W. Va. These works were built to make Bessemer steel for several companies in Wheeling.

Mr. C. A. Thompson has been appointed General Inspector of Motive Power and Equipment of the Philadelphia & Reading Railroad, and will have his headquarters at Reading, Pa. Mr. Thompson was recently Master Mechanic of the Long Island Railroad.

General William J. Sewell, the retiring Senator from New Jersey, who was an unsuccessful candidate for re-election, was for a number of years Superintendent of the West Jersey road. For several years past he has been Vice-President of the Company.

Mr. L. Redfield has taken charge of *Wood and Iron*, published at Minneapolis, Minn., in place of Mr. W. R. Gregory. Mr. Gregory has sold his interest in the paper to some Minneapolis gentlemen, who will put new capital into the paper, and make many improvements.

Mr. James Arkell, of Canajoharie, has been nominated by the Governor of New York as Railroad Commissioner, in place of John O'Donnell, whose term has expired. Mr. Arkell was not confirmed by the Senate and his nomination was withdrawn.

Mr. William O. Seymour has been appointed Railroad Commissioner by the Governor of Connecticut, in place of Mr. John W. Bacon, whose term has expired. Mr. Seymour is a civil engineer, and was for nine years Chief Engineer of the New York, New Haven & Hartford road.

Mr. S. Wright Dunning, for many years Editor of the *Railroad Gazette*, has met with a double bereavement in the death of his father, Josiah D. Dunning, and his mother. Both died on the same day and within two hours, at their home in Aurora, Ill., March 1 last. Both were 84 years old.

Capt. Chas. W. Rogers, First Vice-President of the St. Louis & San Francisco road, died at Pasadena, Cal., Feb. 21, after a long illness. He was 52 years old and had been connected with the road 15 years, serving successively as Purchasing Agent, General Superintendent, General Manager and Vice-President.

Mr. Charles P. Clark has been chosen President of the New York, New Haven & Hartford Railroad Company. He has been a director of the company for several years, and was Second Vice-President for a year. He is best known from his service as President and Receiver of the New York & New England Railroad Company.

Col. A. S. Buford, for a long time President of the Richmond & Danville Railroad Company, is now President of the Virginia Western and the Tennessee Midland, two companies organized to build a railroad from Memphis, Tenn., to a connection with the Shenandoah Valley and the Richmond & Allegheny in the valley of Virginia.

Mr. Rufus Blodgett, who has been elected United States Senator from New Jersey, was for a number of years Master Mechanic of the New Jersey Southern road, and afterwards Superintendent of the same line. For two years past he has been Superintendent of the New York & Long Branch road. Mr. Blodgett has served several terms in the State Legislature.

Mr. George H. Griggs is appointed Master Mechanic of the Central Railroad of New Jersey, with office at Elizabethport, N. J., in place of the late William Woodcock. Mr. Griggs was for a number of years at Hornellsville, N. Y., in charge of the Western and Buffalo divisions of the Erie road. For several years past he has been Master Mechanic of the New York, Providence & Boston road.

Professor Arthur T. Hadley, who has for two years past filled the office of Commissioner of Labor Statistics of Connecticut in a very efficient manner, has retired from that office, the present Governor of the State having appointed as his successor Mr. Samuel N. Hotchkiss. The new Commissioner lacks Prof. Hadley's special qualifications for the office, and has been appointed, apparently, for political reasons only.

Mr. Michael J. Rickard, of Utica, has been nominated by Governor Hill, of New York, for Railroad Commissioner in place of John O'Donnell, whose term has expired. The Governor has withdrawn his previous nomination of Mr. James Arkell. Mr. Rickard is a locomotive engineer on the New York Central and a member of the Brotherhood of Locomotive Engineers. His nomination has not yet been confirmed by the Senate.

Mr. James D. Layng has been chosen President of the Cleveland, Columbus, Cincinnati & Indianapolis Company. He was for a number of years on the Pittsburgh, Fort Wayne & Chicago. From that road he went to the Chicago & Northwestern as General Superintendent. He left the Northwestern to become General Superintendent of the West Shore, and afterwards succeeded Mr. Charles Paine as General Manager of that road.

Colonel Henry G. Prout has been added to the staff of the *Railroad Gazette*, and will be Managing Editor of that paper. Colonel Prout is a civil engineer by education; he was for several years in the service of the Khedive of Egypt, rising to the rank of Colonel in the Egyptian army. He has for some time past had charge of the *Journal* of the Association of Engineering Societies, and has had other practical experience which well fits him for his new position.

General Louis Wagner has been appointed Director of Public Works of Philadelphia. Under the new charter of the city this officer has sole charge of the streets, sewerage, water-works, gas-works, and other departments, and is responsible directly to the Mayor, by whom he is appointed. General Wagner has had much experience in city offices and public works, but is not, we believe, an engineer by training. The appointment seems to meet with local approval.

Shunk & Bryson is the title of a new firm of civil engineers just formed, whose office is established at No. 1 Broadway, New York. The specialties of the firm will be surface and elevated railroads, reports on projected enterprises, the conduct of surveys, location and economical building of roads, preparation of plans and estimates, and superintendence of construction. They will also prepare plans for sewerage and water supply, grading streets, etc., and for bridges and buildings, and do a general consulting business.

Mr. William F. Shunk, the senior partner, has had a wide experience, and is well known both in active service, as engineer in charge of the construction of railroads and other works, and as a writer on engineering topics. He was Chief Engineer in charge of the construction of the Metropolitan Elevated Railroad in New York, and more recently Associate Chief Engineer of the South Pennsylvania Railroad.

Mr. Andrew Bryson has also had much experience in railroad and other work. He was Chief Engineer of the Hartford & Harlem road, and more recently Engineer in charge of the construction of the Kings County Elevated road in Brooklyn.

NOTES AND NEWS.

German Iron Production.—The total production of pig-iron in Germany in 1886 was 3,339,803 tons, against 3,751,775 tons in 1885; a decrease of 411,972 tons, or 11 per cent.

Prices of Cars.—At a recent letting by the Texas & Pacific contracts for a large number of freight cars were given out at the following prices. Flat and gondola cars, $320 to $350; stock cars, $475; box cars $475 to $500 each.

Electric Elevators.—The Sprague Electric Railway & Motor Company, it is said, is running 13 elevators in Boston, both freight and passenger. One of the freight elevators is the largest in the city. They also have 50 other motors in operation.

Hudson River Tunnel.—The New Jersey end of the incomplete tunnel under the Hudson River was pumped clear of water some time ago, and arrangements are in progress to resume work. How soon this is done, or whether it is done at all, depends upon whether the money can be raised.

Triple Expansion Engines on Lake Steamers.—The Cleveland Shipbuilding Company has let contracts for the engines of a new lake steamer which it is now building. The engine is of the triple-expansion class, the cylinders being 24, 38 and 61 in. diameter and 42 in. stroke.

A New Iron Vessel.—At the yard of the Harlan & Hollingsworth Company in Wilmington, Del., on March 21, the new iron steamer *George* was launched. The vessel is 280 ft. long between perpendiculars, 292 ft. over all, 40 ft. beam and 17½ ft. depth of hold; it is to run on the Bay Line between Baltimore and Norfolk.

Repaving New York Streets.—A movement is on foot, it is said, to repave a large number of the streets of New York. This work is certainly much needed. The persons who are urging it believe that the present is a good time to undertake it, especially as the department of Public Works is now under so able a head as Gen. Newton.

Arthur Kill Bridge.—The Secretary of War has authorized the building of the bridge over the Arthur Kill on the Baltimore & Ohio line to Staten Island, on the original plan, subject to the requirements of the rule laid down by the War Department in July, 1886. The bridge, according to the plan, will have four fixed spans and a draw-span.

Alabama School of Mines.—The Board of Trustees of the

University of Alabama have decided to establish a school of mines in connection with the University. A full course of instruction in mining and metallurgy will be arranged. This action is particularly appropriate in Alabama, whose mineral resources are great and are just beginning to be developed.

Wrought-Iron Car Wheel-Centers.—The Secretary of the Treasury has decided that car-wheel centers, consisting of iron forgings which have been advanced by other processes of manufacture—bored out for the axle, hubs faced, rims turned and finished, with a flange or rim bolted on to prevent slipping of tires—but not completed by putting on the tires, are subject to duty at the rate of 45 per cent. *ad valorem.*

A Large Bronze Casting.—The Henry Bonnard Bronze Company in New York recently made what, it is claimed, is the largest bronze casting ever made in America. The casting is part of an equestrian statue of General Meade, for Philadelphia. In making it 7,500 lbs. of metal were used, the composition being 90 parts copper and 10 parts tin. The statue when finished will be 16 ft. high, and weigh about 10,000 lbs. in all.

Railroad Bridges in Massachusetts.—The Massachusetts Railroad Commission on March 21 sent out the following circular: "To the Managers of the Several Railroads in Massachusetts: You are requested to send to this office, at the earliest practical moment, the strain sheets and records of the first and latest tests of all the bridges on the roads operated by you. State also whether any parts of said bridges which are essential to safety are so covered as to be concealed from inspection. Describe also the style of flooring."

Mineral Products of Ohio.—Mr. Thomas B. Bancroft, Chief Inspector of Mines of Ohio, makes the following statement of the products of that State for 1886.

Coal, tons	8,435,211
Iron ore, tons	344,484
Limestone, tons	625,350

The limestone is only that used for flux in smelting iron or burned for lime, the large quantity quarried for building and paving purposes not being included. Coal was mined in 28 counties and iron ore in 14 counties.

Old Bridges and Modern Engines.—The Maine Railroad Commissioners in their last report call attention to the fact that on the railroads of that State there are many bridges which, while they may have been well designed in the first place and well taken care of since, were yet intended for locomotives very much lighter than those in general use at the present time. Whether these bridges are safe under the rolling stock now in use, and whether they are not overloaded and subject to failure at any time, are serious questions, the Commissioners think, and should be carefully considered.

Rapid Transit in New York.—Mayor Hewitt, of New York, has appointed Messrs. Jackson S. Shultz, H. K. Thurber, Walter Stanton, E. Ellery Anderson and William E. Worthen, C. E., Rapid Transit Commissioners to lay out routes for steam-railroad connections between the elevated roads and the ferries, south of Fourteenth Street. The plan proposed by the Manhattan Company is for a line along the North River front from the Battery to Christopher street, connecting with the Sixth Avenue line on the west side, and a loop from the Third Avenue line along the East River from Chatham Square to the Battery.

Blast Furnaces of the United States.—The *Iron Age* reports the number of furnaces in blast on March 1 as follows:

Fuel.	No.	Weekly capacity.
Anthracite	141	43,724
Bituminous	146	79,682
Charcoal	51	9,546
Total	338	132,952

As compared with January 1, there was an increase of 11 anthracite and 9 bituminous furnaces in blast, with no change in the charcoal furnaces.

Bessemer Steel Production in England.—The British Iron Trade Association reports the total production of Bessemer steel ingots in Great Britain in 1886 at 1,570,520 tons, an increase of 20½ per cent. over 1885.

Of the production last year 730,343 tons, or about 46 per cent., were converted into steel rails. The increase in rail production over 1885 was small, being only 3¼ per cent.

Of the total output of Bessemer steel ingots 723,337 tons were made in the first half of the year, and 837,183 tons in the second half, showing an increase in activity which continued up to the close of the year.

A Fast Yacht.—The Herreshoffs, at Bristol, R. I., have contracted to build, for a New York gentleman, a steam-yacht, which is to make greater speed than any heretofore built. She will be 100 ft. long, and in general dimensions about the same as the *Stiletto*, built last year by the same parties.

The builders have guaranteed a rate of speed in excess of that of the *Stiletto*, which has attained 26 miles an hour over the measured mile. The yacht will be arranged for comfortable cruising as well as immense rapidity of motion. Her engines will be of the triple expansion type, thus differing from those of the *Stiletto*, which have two cylinders only. The work is to be rushed so that the new craft will be ready for service the latter part of June.

Bridge Contracts.—The Edgemoor Iron Company, Edgemoor, Del., has taken the contract for the superstructure of the bridge over the Missouri River, on the Atchison, Topeka & Santa Fe Extension to Chicago. The bridge will have three spans of 400 ft. each over the channel, one span of 250 ft., one of 200 ft., and two of 175 ft. each. In the approaches there will be 1,900 ft. of iron trestle. There will be no draw, the bridge being 95 ft. above low water in the river.

The bridge over White River, at West Hartford, on the Central Vermont road, which was burned down in the recent accident, will be replaced by a riveted lattice deck bridge, 650 ft. long, in five spans. The Vermont Construction Company, of St. Albans, will build the bridge.

A Large Anvil Block.—The Otis Iron & Steel Company recently made a steel anvil block, which is said to be the largest steel casting ever made in this country. The block is for a steam hammer which the Morgan Engineering Company is building for the Otis Company's works. It weighs 68,200 lbs., is 8 ft. square and 3 ft. 10 in. high. The analysis in carbon is 0.12 to 0.15. The quality of the steel is about the same as that of the company's soft open-hearth steel, no special effort being made to have the metal free from blow-holes. The steel was melted in two furnaces, and the total amount charged was 78,525 pounds. The total time of pouring the block, from the time the metal commenced to run from the first furnace until all the metal was in the mold, was 4 minutes and 20 seconds.

Iron Forges.—The *Bulletin* of the American Iron & Steel Association says: "The primitive manner of making wrought iron from ore in forges, practiced chiefly in the Lake Champlain District of New York and in the mountainous districts of North Carolina and Tennessee, is fast becoming a thing of the past. The quantity of iron made by the New York forges is decreasing yearly. In North Carolina the Maiden Creek Forge has rotted down; the Catawba Valley Iron Works are suspended; Owl Creek Forge, at Murphy, Cherokee county, will make no more blooms, and the owner, Mercer Fain, desires to let the valuable ore and timber lands connected with the forge. The other forges in that part of the State are not in operation. Very little iron was made in the Tennessee forges during 1886."

Georgia Technological School.—This school is to be located in Atlanta, instead of at the State University at Athens, the Commission having decided that a city presents better opportunities for technical instruction.

The funds provided and ready for the building and its appointments are as follows: From the State, $65,000; from the city, $50,000; from the citizens of Atlanta, $20,000; total $135,000. The Institution will also have an annuity of $25,000, with which Atlanta has endowed it for a period of 20 years.

The various details, including the erection of the buildings, purchase of machinery and all other appointments, and the final selection of instructors will receive the closest attention on the part of the Commission, the intention being to make the school one of the best of its kind

Steel for Guns and Armor Plates.—On March 22, at the Navy Department in Washington, the bids for furnishing armor plates and heavy steel forgings for guns were opened. Five bids were received, three for the gun forgings and two for the armor plates. The bids for the gun-steel (1,310 tons) were as follows:

Midvale Steel Works, Philadelphia	$1,397,240
Bethlehem Iron Company, Bethlehem, Pa	902,231
Cambria Steel & Iron Company, Johnstown, Pa	851,514

For the armor plates (4,500 tons), the bids were as follows:

Bethlehem Iron Company, Bethlehem, Pa	$3,610,708
Cleveland Rolling Mill Company, Cleveland, O	4,021,560

The Bethlehem Iron Company offers to have its forging plant completed in 15 months, or half the time required by the Department. The contracts have not yet been awarded, and the decision will probably not be made public until the middle of April.

The Berdan Torpedo Boat.—Gen. Berdan recently exhibited in Washington a working model of his torpedo boat, which is intended to do effective service in cases where other

forms of torpedo have failed—that is, where the craft attacked is protected by a network of chain suspended beyond the hull by spars. The model is that of a vessel 150 ft. in length, 20 ft. in breadth and 16 ft. in depth, and intended to attain a speed of 24½ knots an hour. The novel feature of the craft consists of a pair of brass tubes arranged vertically on the sides and opening downward, capable of firing torpedoes containing 200 lbs. of dynamite or other high explosives. These torpedoes are connected with a cross-piece on the bow by stout steel cables. When the projecting spar, corresponding to an ordinary bowsprit in appearance, comes in contact with the hull of the vessel attacked, it automatically reverses the engine and fires the 100-lb. charges of rocket powder in the torpedo cases. The torpedoes are driven downward, but yielding to the direction imparted by the cables, swing around under the protective netting and strike beneath the keel of the attacked vessel, exploding their charges by percussion directly under its botom.

Shipbuilding in Great Britain.—The number of new vessels built in Great Britain in 1886 and registered there was as follows:

	Steam		Sail		Total	
	No.	Tons.	No.	Tons.	No.	Tons.
Steel	124	162,073	31	30,588	155	192,661
Iron	119	82,201	55	97,713	174	179,914
Wood	30	1,467	229	14,411	259	15,878
Total	273	245,741	315	142,712	588	388,453

The wooden vessels, it will be seen, were generally of small size, averaging only a little over 60 tons each.

The total tonnage of vessels built as reported to the British Iron Trade Association, was 481,233 tons. The difference between this and the statement given above is accounted for by the fact that 80,701 tons were built for foreign account, and not registered in Great Britain, while several vessels launched near the close of the year were not registered until 1887. The total tonnage built shows a decrease of 11 per cent. from 1885.

The total number of steel vessels built in 1886 for home and foreign account was 219, with a total tonnage of 265,460; an average of 1,213 tons per vessel.

Plans for Car Heating Wanted.—The Acting Secretary of the Treasury has issued the following circular "to whom it may concern:"

"Congress (House of Representatives) having, on Jan. 21 last, by resolution, requested the Secretary of the Treasury to make inquiries of constructors of passenger cars and of steamboats, and of other persons capable of giving useful information as to the best methods of building railroad cars and heating the same, and constructing steam vessels so as to prevent loss of property and life by fire, the Department takes this method of inviting correspondence upon the subject matter of the resolution referred to. Parties offering suggestions are requested to send with them sketches or drawings of their designs when practicable.

"All communications upon the subjects referred to herein should be addressed to the Secretary of the Treasury, Washington, D. C., also indorsing upon the outside 'Plans for heating railroad cars, etc.'

"Communications received after Nov. 1, proximo, will not be guaranteed consideration, as a report will have to be made to Congress at the commencement of the session in December."

Iron Ore Supply.—Major John W. Powell, Director of the United States Geological Survey, has furnished the following for publication:

"The great increase in the production of pig-iron, from 4,529,869 short tons in 1885, to 5,600,000 short tons during the year 1886, has led to much inquiry as to the source of the ores which made this increase possible, for it is a well-known fact that even the ordinary production is a drain upon the ore deposits sufficient to exhaust the present sources of actual supply in a short period—perhaps in 30 years, more probably in much less time. The Government has given sufficient attention to the general geology of the country, however, to afford a good grasp on the distribution of the iron ores, and the geologists have also defined the character of the ores so well as to direct the explorers accurately to the profitable fields. The statement was made last year by me that within 30 years the necessary exploration for new iron-ore mines would exceed that of Great Britain, where every available deposit is being traced to the farthest extent. The years 1885 and 1886 have shown the justice of this prediction in the development of new fields to support the increased production. The new Gogebic District, which produced 1,022 tons in 1884, increased to 111,661 tons in 1885, and increased this fourfold in 1886, has been the scene of unparalled developments, and the same is true of the Vermilion District of Minnesota. The confidence with which capital has been invested in these new claims is due to the advice of the geologists to extend the mines in this direction. That the new mines are the result and not the cause of the increased production of iron and steel is shown by the increased imports of Spanish ores during the last year as the result of higher prices. This shows that the remedy for prospective exhaustion is still further exploration for the mines to which the geologist points in various parts of the country. Many of the large deposits have been neglected as not suitable for making steel by the ordinary process, and in others others the percentage of iron is not attractive. But much attention will undoubtedly be given to these ores within the next few years. This tendency is seen at one locality in Tennessee by the increase from 70,757 long tons in 1884 to 94,319 long tons in 1885, and even the silicious ores at Cornwall, Pa., show increased use."

Electric Light for Cars.—The Boston & Albany Company, having had a passenger car in service lighted with the electric light, has decided, it is said, to equip a large number of cars in the same way. The trial car (and the others are to have substantially the same apparatus) carries 24 incandescent lamps of 16-candle power each, the power for these lamps being furnished by a Jullien storage battery carried underneath the car. This storage battery will keep all the lights burning for 10 hours; it has 60 cells, each cell consisting of 19 plates, weighing in all 27 lbs., and measures 6¼ by 5¾ in., and 8 in. high. These cells are combined in boxes for convenience in carrying and changing, and the whole battery weighs about 1,800 lbs.

The car is lighted brilliantly, and in ordinary service a smaller number of lights would be sufficient. In a month's service there has been no trouble whatever with the lights, and it is claimed that the work necessary to recharge the batteries is much less than that required to take care of lamps, while the cost is no greater.

The apparatus was furnished by the Jullien Electric Light Company, of New York, which owns the patents covering the Jullien storage battery in this country. That company is equipping cars for the Baltimore & Ohio, the New York Central and the Pennsylvania roads, and the new system is to have a trial on all those lines.

Interstate Commerce Commissioners.—President Clevеand has appointed the following Commissioners under the Interstate Commerce law, which takes effect April 5: Judge Thomas M. Cooley, of Michigan, for six years; Hon. Wm. R. Morrison, of Illinois, for five years; Augustus Schoonmaker, of New York, for four years; Aldace T. Walker, of Vermont, for three years; Walker L. Bragg, of Alabama, for two years.

Judge Cooley was for 15 years a member of the Michigan Supreme Court; he was for a time Arbitrator of several of the Western traffic associations, and is now Receiver of the Wabash, St. Louis & Pacific lines east of the Mississippi. He is considered high authority on railroad law and traffic questions.

Colonel Morrison is well known from his service of 16 years in Congress, where he has taken a prominent part.

Mr. Schoonmaker has served as State Senator and Attorney General of the State of New York, and is a lawyer of high standing.

Mr. Walker is also a lawyer of high standing. He was for some time Counsel for the Vermont & Canada stockholders in their long fight against the Vermont Central Receivers and the Central Vermont.

Mr. Bragg has been for four years Chairman of the Alabama Railroad Commission, where he has done excellent work.

Power Brakes for Locomotives.—Mr. James Hilbert, of Division 263, writes to the *Journal* of the Brotherhood of Locomotive Engineers as follows:

"In common with a great number of our Brotherhood I am pleased to see the rapid introduction of power brakes for locomotives, and how generally they are now coming into use. I have had an improved form of steam-brake upon the engine which I am running now for several months, and have already had several opportunities of observing its usefulness. I will relate one instance which happened with me quite lately and which will illustrate the advantage of such a device upon the engine. A short time ago I was coming down the mountain with my engine light, and I saved a runaway with the brakes on my engine in this manner: A train of engine and 75 cars was following me, and their hand brakes could not hold the train, when the engineer reversed the engine and blew both of his steam chests off. I saw the situation and prepared to see what virtue there was in my steam driver and tender brake, so I governed the speed of my engine until they came against me, when I stopped the whole outfit in a very short distance with my steam brakes, in time to save running into another train

ahead of me, and thus averted what might have resulted in a terrible smash-up all around. I believe that all engines upon the roads should be provided with effective power brakes, especially these heavy mogul and consolidation engines which are coming into such general use."

The Bussey Bridge Accident.—On the morning of March 14, as a local train (locomotive and nine cars), on the Dedham Branch of the Boston & Providence road was passing over the Bussey Bridge near Roslindale, Mass., the bridge gave way. The engine and three cars passed over, but six cars went down some 40 ft., and were completely wrecked. The cars were full of passengers on the way to their work in Boston, and of these 28 were killed and 114 more or less injured. Five of these have since died. The bridge was a deck-bridge, crossing a highway road at an angle at 45°, and was 110 ft. long. The two trusses were built at different times and of different patterns, the latest one having been in place since 1876. It is charged that the bridge was in bad condition, and to substantiate this, a broken hanger has been shown which was evidently cracked for some time before the final failure. Others claim that a car was derailed on or near the bridge, and that the shock of this derailed car threw the trusses from their seats. It is to be noted that the cars were heated by old-fashioned stoves and that two (one account says three) of them caught fire. The fire was, however, quickly put out by a fire-engine from the village close by.

The Massachusetts Railroad Commissioners are now making an examination into the causes of the disaster.

Blast Furnaces in 1856 and in 1886.—The *American Manufacturer* gives a table showing the number of blast furnaces in the United States in 1856 and in 1886, the totals being as follows:

Fuel.	1856.	1886.
Charcoal	416	174
Anthracite	121	124
Bituminous and Coke	43	280
Total	580	578

The *Manufacturer* says: "The totals show that the charcoal furnaces very largely outnumbered the anthracite and bituminous furnaces in 1856, there being 416 of the former, compared with 121 anthracite and only 43 bituminous, while in 1886 the totals had changed to 174 charcoal furnaces, 124 anthracite and 280 bituminous, the charcoal and bituminous furnaces changing places as to number. Another noticeable feature is the fact that there were no more productive furnaces in the country in 1886 than there were in 1856, but of course the production was many times greater.

Taking the states separately, Maine had 1 furnace in 1856 and 1 in 1886; New Hampshire had 5 in the former period, and none in the latter; the same is true of Vermont; Massachusetts had 10, against 8 now; Connecticut 15; against 9 now; New York had 43, against 39; Pennsylvania was far in the lead, and has kept it ever since; Maryland had 30, against 19. Several of the Southern States also had a greater number of furnaces in 1856 than in 1886. Tennessee had 41, against 17; Kentucky 30, against 6; Georgia 7, against 4; South Carolina 4, against none. Twenty-two States made pig-iron in 1856 and twenty-six States and Territories produced it in 1886.

"The production of pig-iron in 1856 was 814,017 tons; in 1886 it was 6,366,688 tons, or near 8 times as much.

"Of the total quantity of pig-iron produced in the United States in 1856 Pennsylvania made over 55 per cent; of the total produced in 1886 she made nearly 52 per cent. Ohio produced more in 1886 than the whole country produced in 1856, and Allegheny County, Pa., will do the same thing this year."

Nail Production in the United States.—The *Iron Age* says: "The American Iron & Steel Association has published the statistics of the production of cut nails for 1886. Aside from the very great increase in the make which the figures show—from 6,696,815 kegs in 1885 to 8,160,973 kegs in 1886—their principal interest lies in the evidence of the great progress which steel has made as the material of which they are made. The change from iron to steel has been uneven, geographically considered. In the great Wheeling District the product consisted of 1,841,402 kegs of steel nails, and only 17,149 kegs of iron nails. With its greatest competitor, the Central Pennsylvania District, the figures are nearly reversed, there having been made only 142,179 kegs of steel nails, and 1,347,303 kegs of iron nails. Yet the year 1886 was really one of preparation, outside of the Wheeling District, and the heavy demand for rails, by making a supply of nail slabs scarce, tended to cut off those works not producing their own steel. Quite a number of plants have been finished in 1886, or are now building, with the object of exclusively or partially supplying the raw material for steel nail manufacture. Among them are one in Massachusetts, one in Virginia, two in Pittsburgh and several in Illinois and Ohio. Besides this, considerable quantities of foreign slabs were bought for works in Pennsylvania and elsewhere, prior to the rise, of which a heavy percentage is being worked up during this first quarter of the current year. There is every prospect, therefore, that the percentage of steel, which was 36 per cent. of the total in 1886, will advance considerably during 1887.

"This movement entails a concentration of manufacture in the hands of fewer and larger producers. It will be readily understood, too, that it brings into closer relations the nail trade, and that leading industry, the rail manufacture. Last year's make of steel nails must have called for at least 150,000 gross tons of slabs. Another point worthy of consideration is the progress of the wire nail. It is estimated that in 1886 the product was not less than 400,000 kegs, which would make the total make of cut and wire nails roughly 8,500,000 kegs, an enormous aggregate. Authorities in the wire trade claim that this year will see the product of that class of nails rush up to 1,000,000 kegs. While this statement will be received with reserve, the fact must be recognized that the contest of the future will be between the steel cut nail and the steel wire nail. It remains to be seen which is the cheaper form, all things considered, the nail plate or the wire."

Bridging the Mississippi.—The report to the Secretary of War on the proposed new bridge at St. Louis is signed by Colonel H. L. Abbott, Major A. Mackenzie, Major A. M. Miller and Captain E. H. Ruffner, U. S. Engineers. From this report the following extracts are taken:

"The importance of a free, unobstructed navigation of the lower Mississippi River is immense. It has been recognized by Congress by large annual appropriations. It alone affords protection against extortionate charges for transportation by corporations. A slight difference in cost of construction in the interest of a single locality should have no weight when considering a question of this national importance. * * *

"The channel is constantly shifting, and a draw properly placed now might be entirely out of place in a few months, making the bridge impassable. Uncertain and costly works of channel regulation are therefore inseparable from a low bridge.

"The drift running out of the Missouri and past St. Louis at every rise would render it impossible, without great danger to life and property, for a boat to control its tow by backing; but this is the only safe mode of passing a draw in a strong current. There being no drift on the upper Mississippi, this difficulty does not affect existing draw-bridges above the mouth of the Missouri. * * *

"The Board has reason to believe that if a drawbridge was built, it is probable that the channel might at times leave the draw-span and thus make the drawbridge impassable.

"The Board calls attention to the fact that an essential feature of the plan of a low bridge is that the channel should be held through the draw-spans. It is not certain that this can be done at all; certainly not without great cost.

"The Board is decidedly of the opinion that a low bridge with a draw in it should not be authorized or allowed below the mouth of the Missouri River. Such a structure would be a serious and grave obstruction to navigation and a direct and oppressive tax upon all river interests. Justice to navigation interests requires that the proposed bridge should be no greater tax upon commerce of the river than is absolutely necessary. Channel spans of 500 ft. clear width, giving a clear headway of not less than 50 ft. at high water, are the least dimensions that should be authorized, and with recent progress in engineering and the introduction of the cantilever principle it is not expecting too much to suggest that spans of even more than 500 ft. may be found to be both practicable and economical.

"The Board desires to emphasize the difference of the Mississippi River above and below the mouth of the Missouri River. Above, it is a quiet river, comparatively free from sediment and drift; the oscillation between high and low water does not exceed about 22 ft. Although low bridges on such a stream are obstructions to navigation, they are not intolerably so. Below the mouth of the Missouri all this is changed. The rise and fall increases to 42 ft. at St. Louis, and over 50 ft. at Cairo; the current doubles in velocity; the volume of sediment is vastly increased; drift frequently runs; the bed is constantly shifting. In a word, the river entirely changes its character, and low bridges must be regarded as an intolerable nuisance to navigation interests.

"The Ohio River which, in its lower course, resembles the lower Mississippi, is protected by a general bridge law forbidding the construction of low bridges, and, in the judgment of the Board, such a law, properly adapted to suit the requirements of the Mississippi below the mouth of the Missouri River, would be useful legislation, in view of the increasing demand for bridges on the lower Mississippi River."